

Using Reforecasts to Improve CPC's Week-2 Forecasts

NOAA's 38th Climate Diagnostics and Prediction Workshop

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Climate Prediction Center



Outline

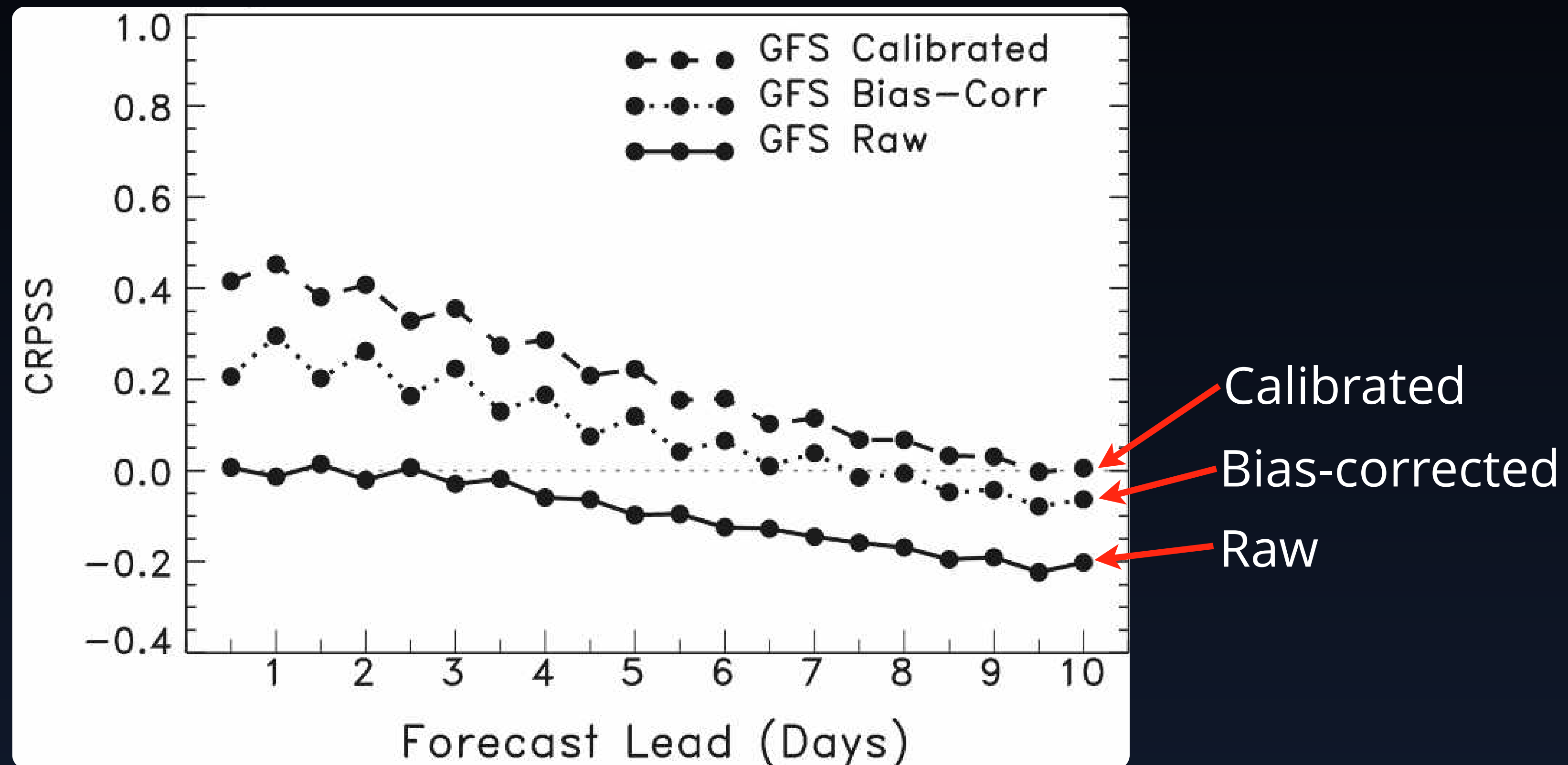
1. CPC's original reforecast-based tool
2. CPC's Reforecast Calibration Project
3. Evaluation of CPC's new reforecast-based tool

Importance of Reforecasts

- Historical forecasts generated with a frozen model
- Useful for diagnosing systematic errors
- Can be used to improve model skill through post-processing

Importance of Reforecasts

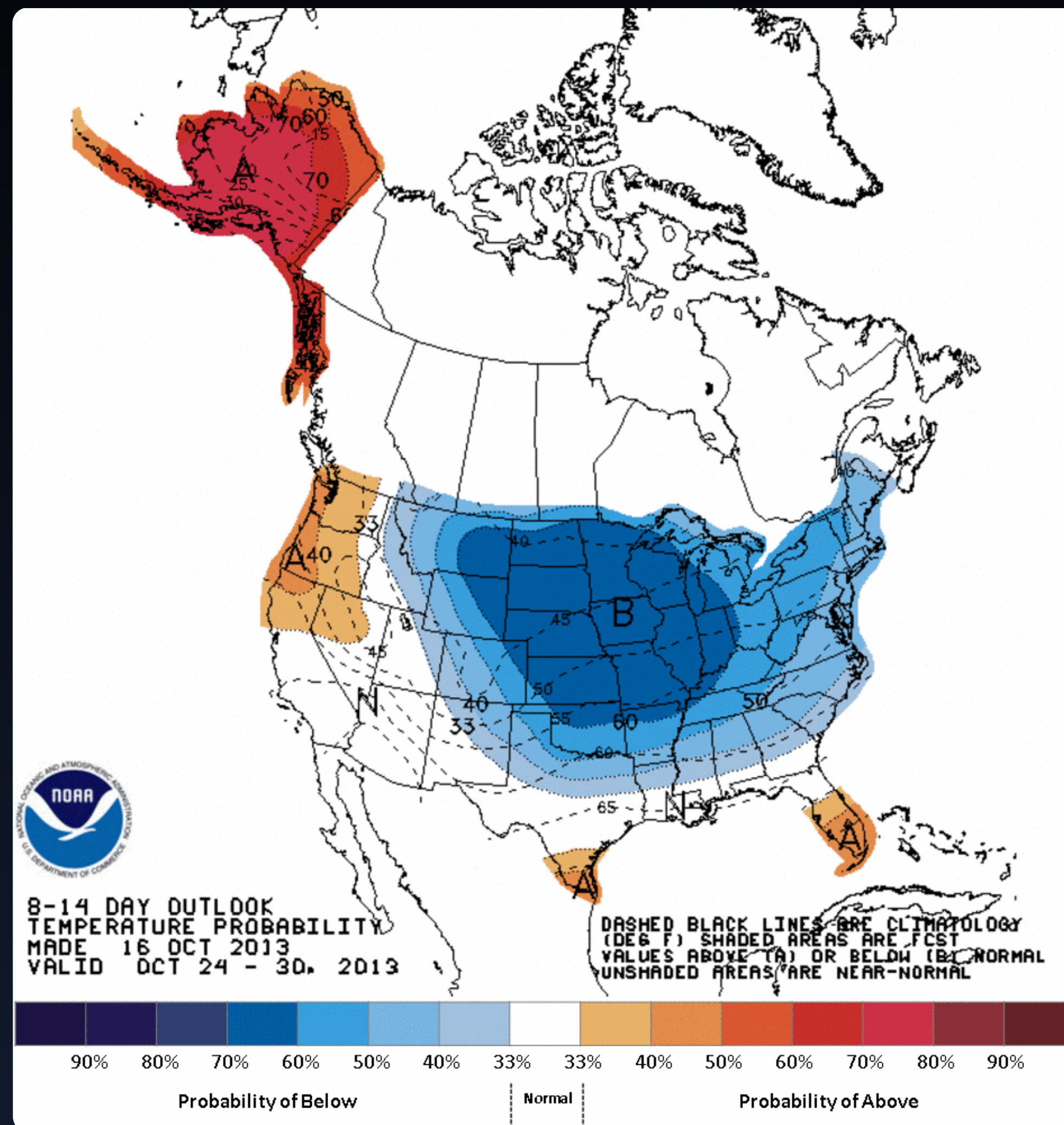
- Hagedorn et al. 2008 - significant improvement in GEFS 2m Temperature forecasts using *bias-correction* and *calibration*



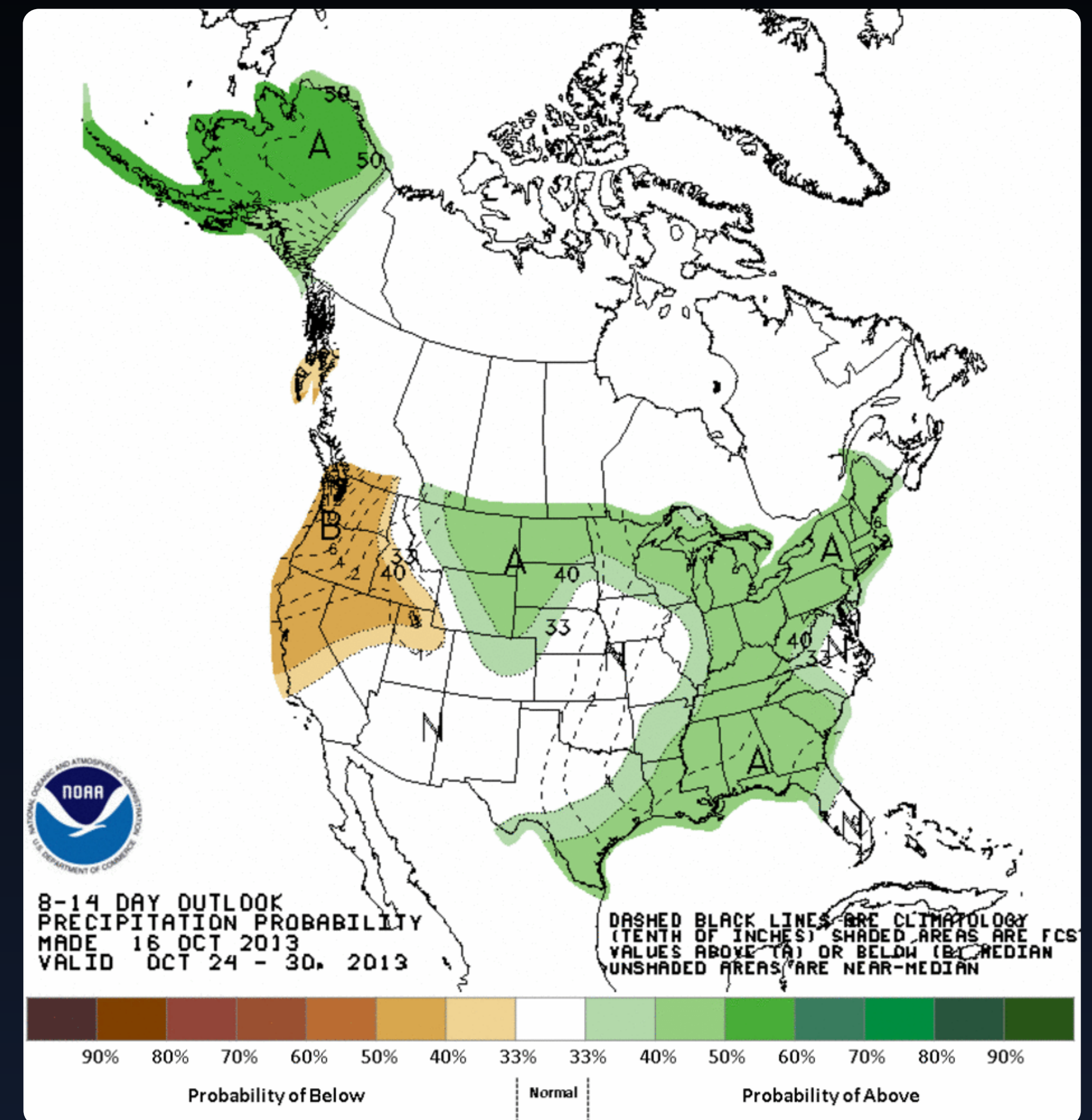
Hagedorn et al. 2008 - CRPSS for 2m T GEFS forecast

CPC's Week-2 Forecast

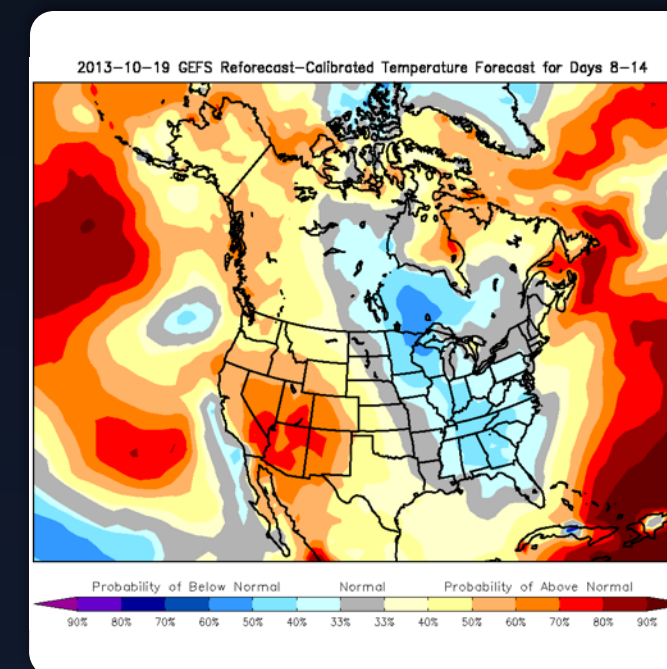
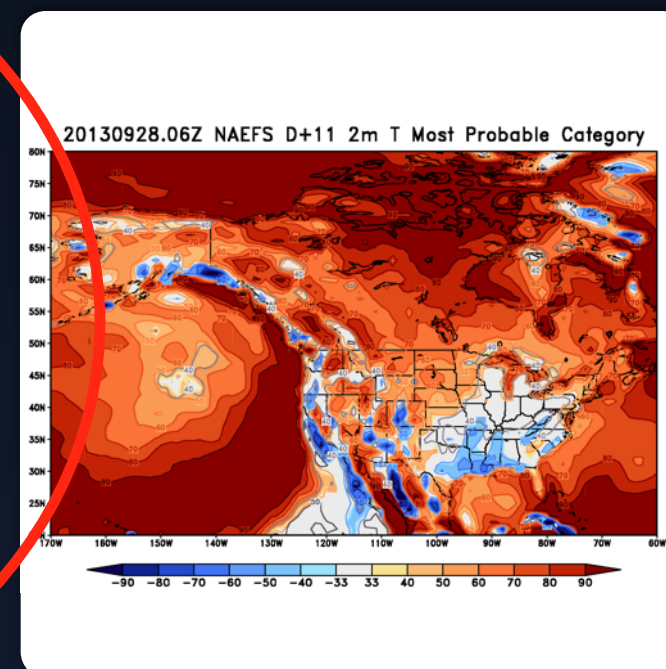
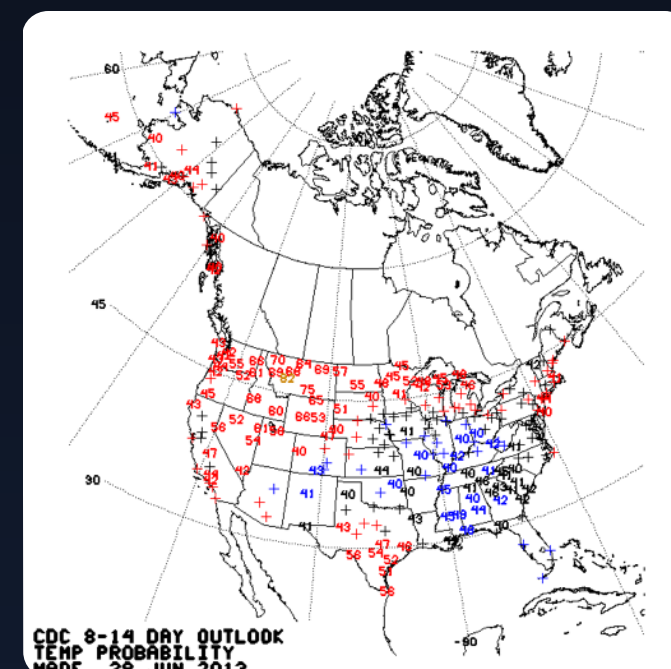
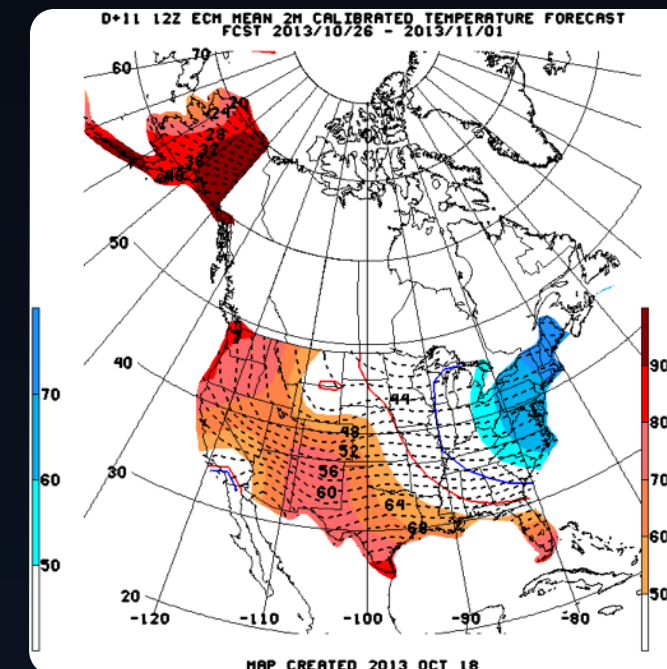
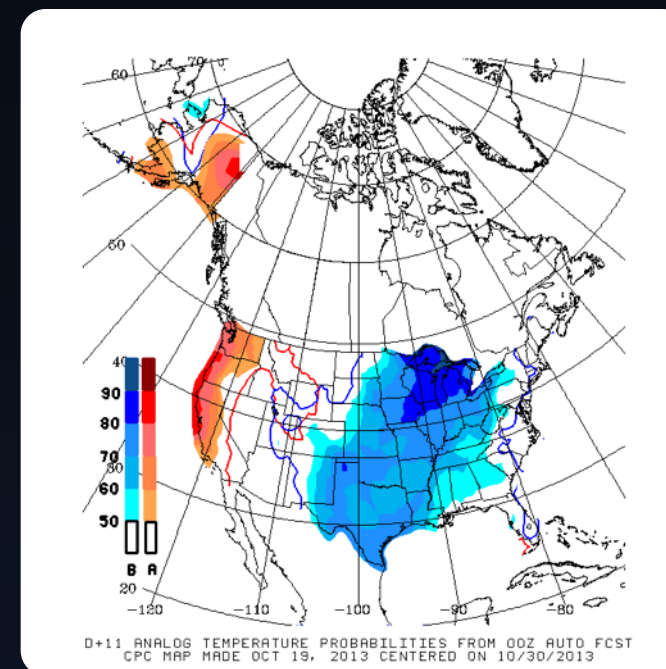
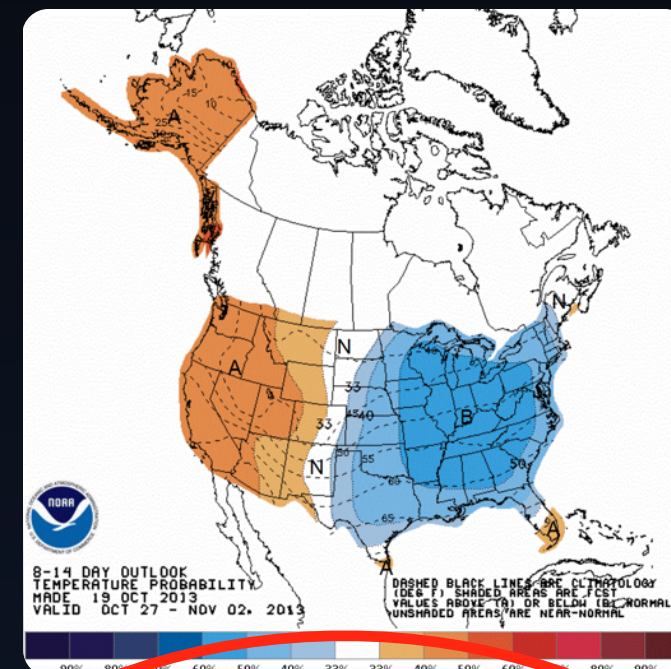
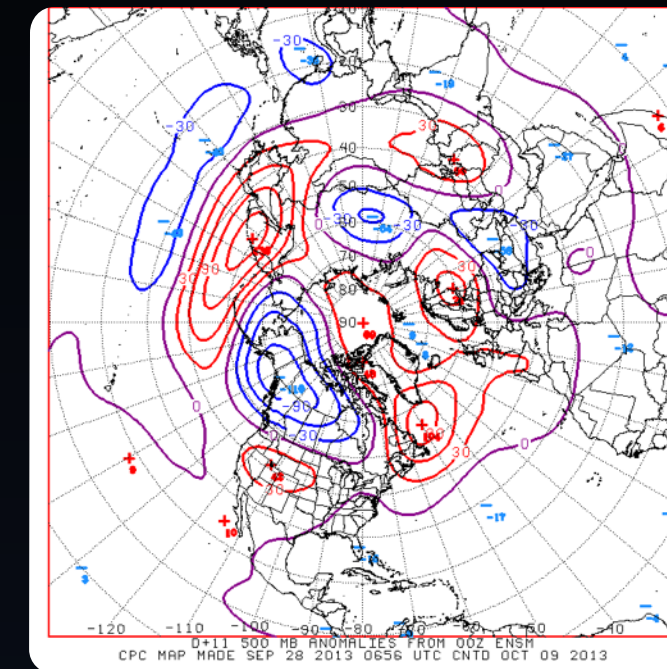
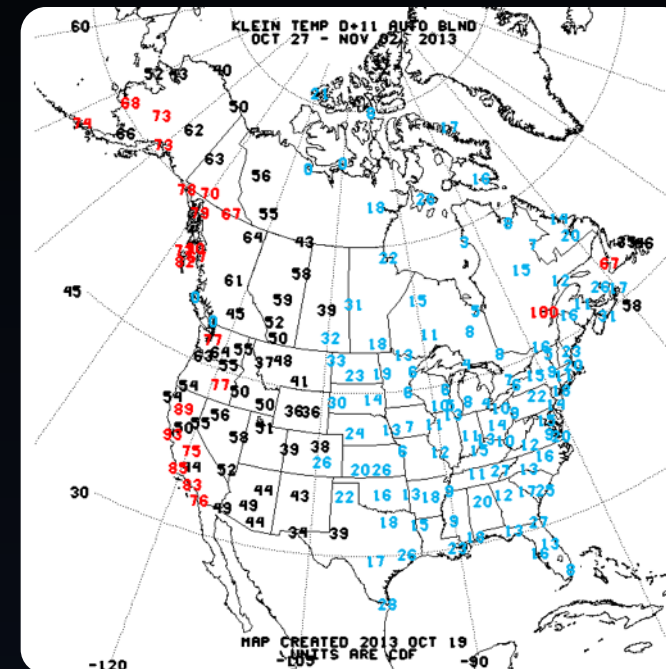
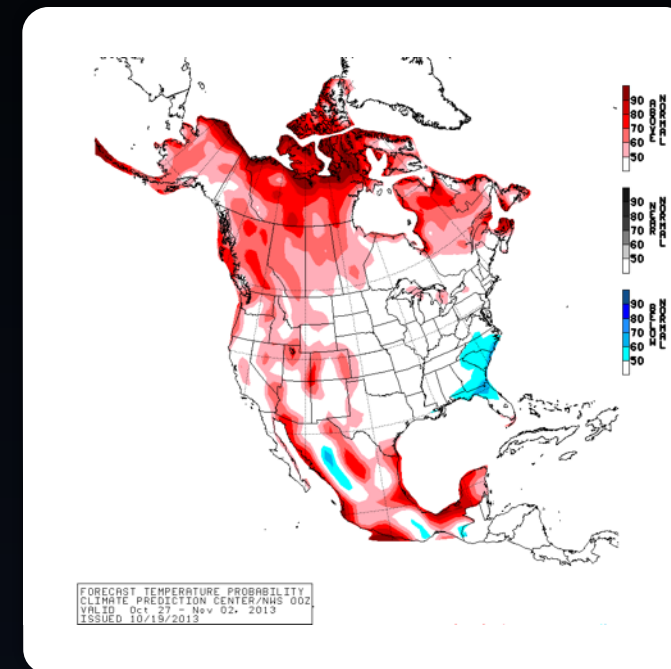
Temperature



Precipitation

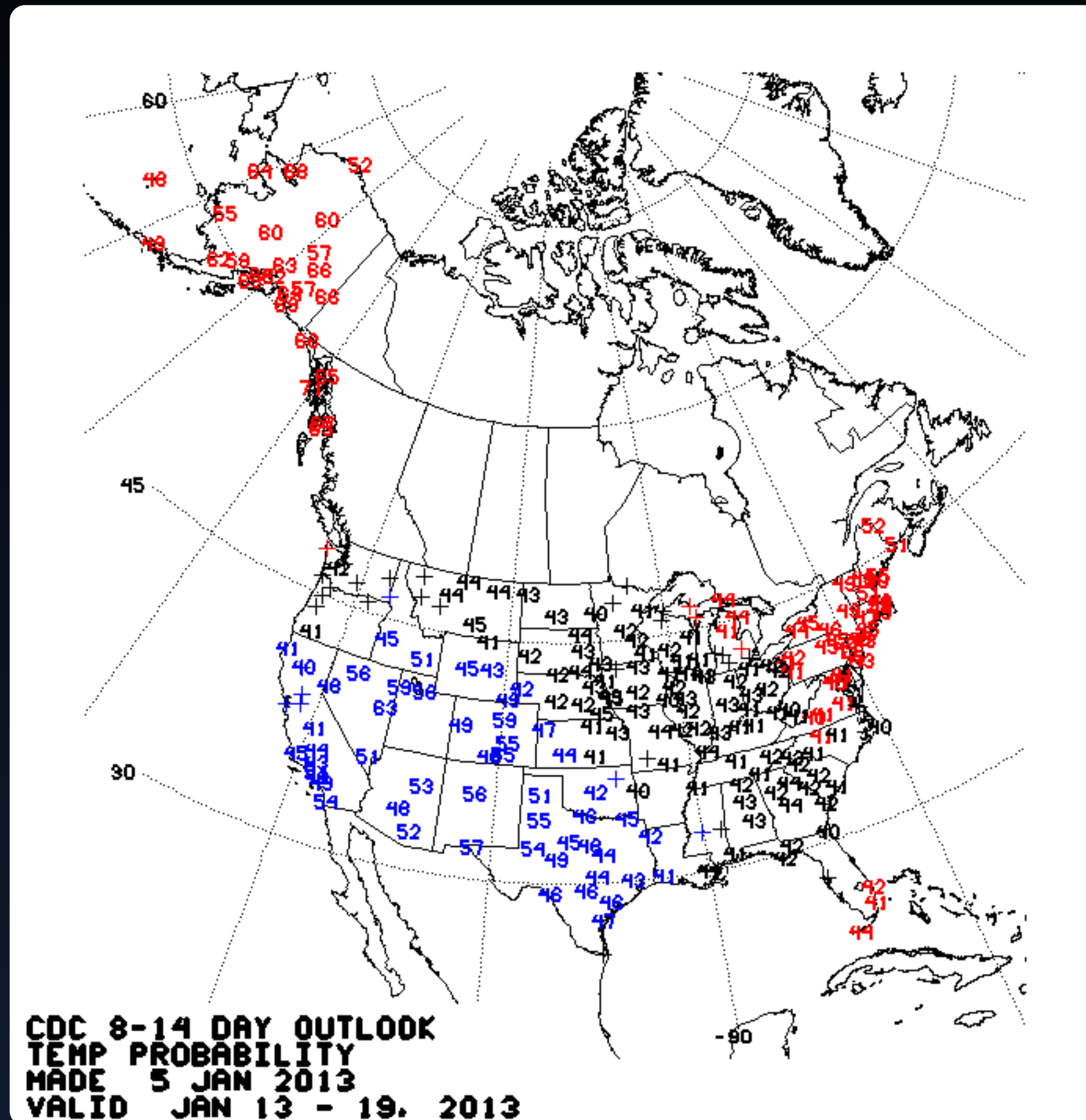


CPC's Week-2 Forecast Tools

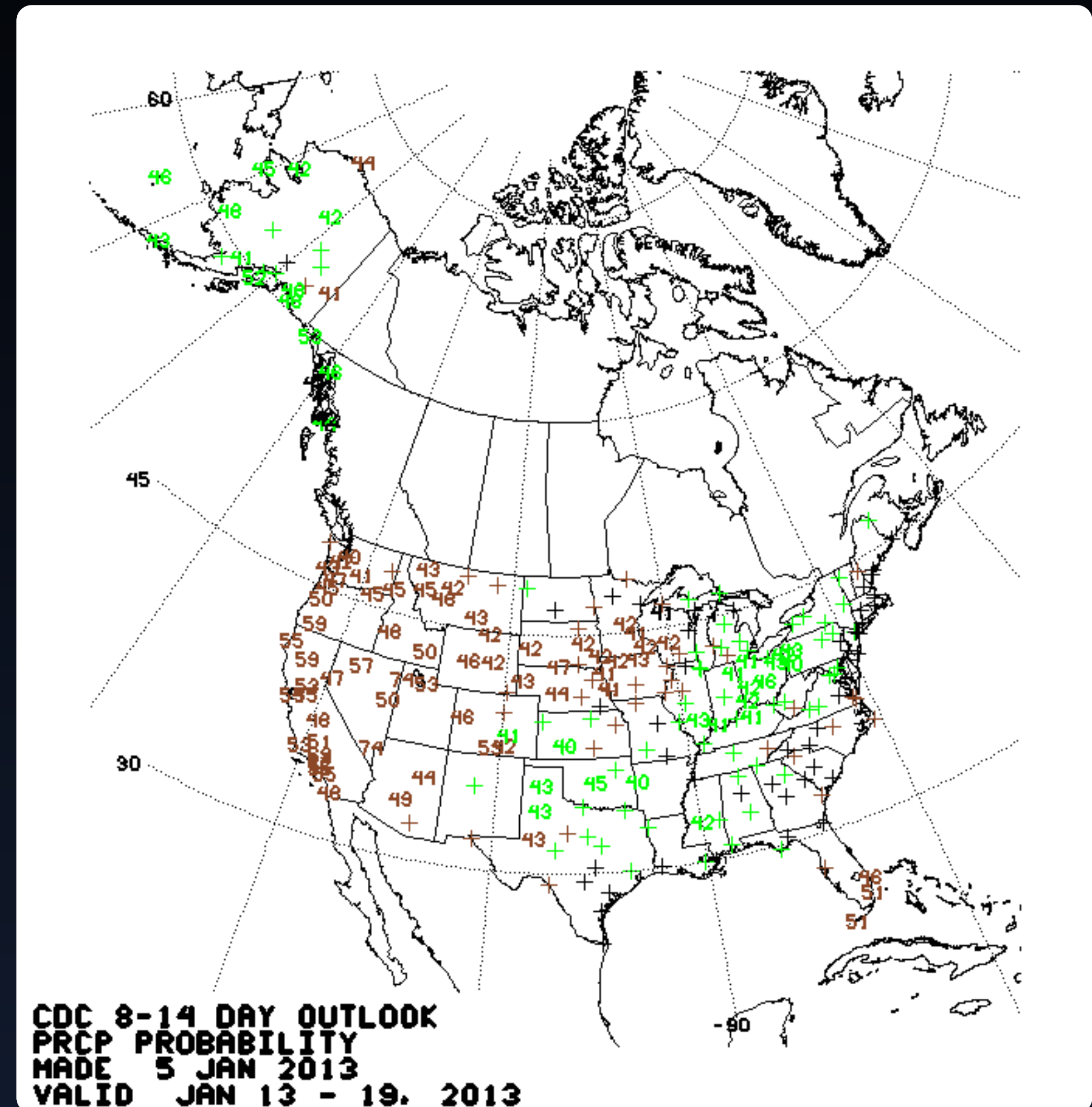


Reforecast-1 Tool

Temperature



Precipitation

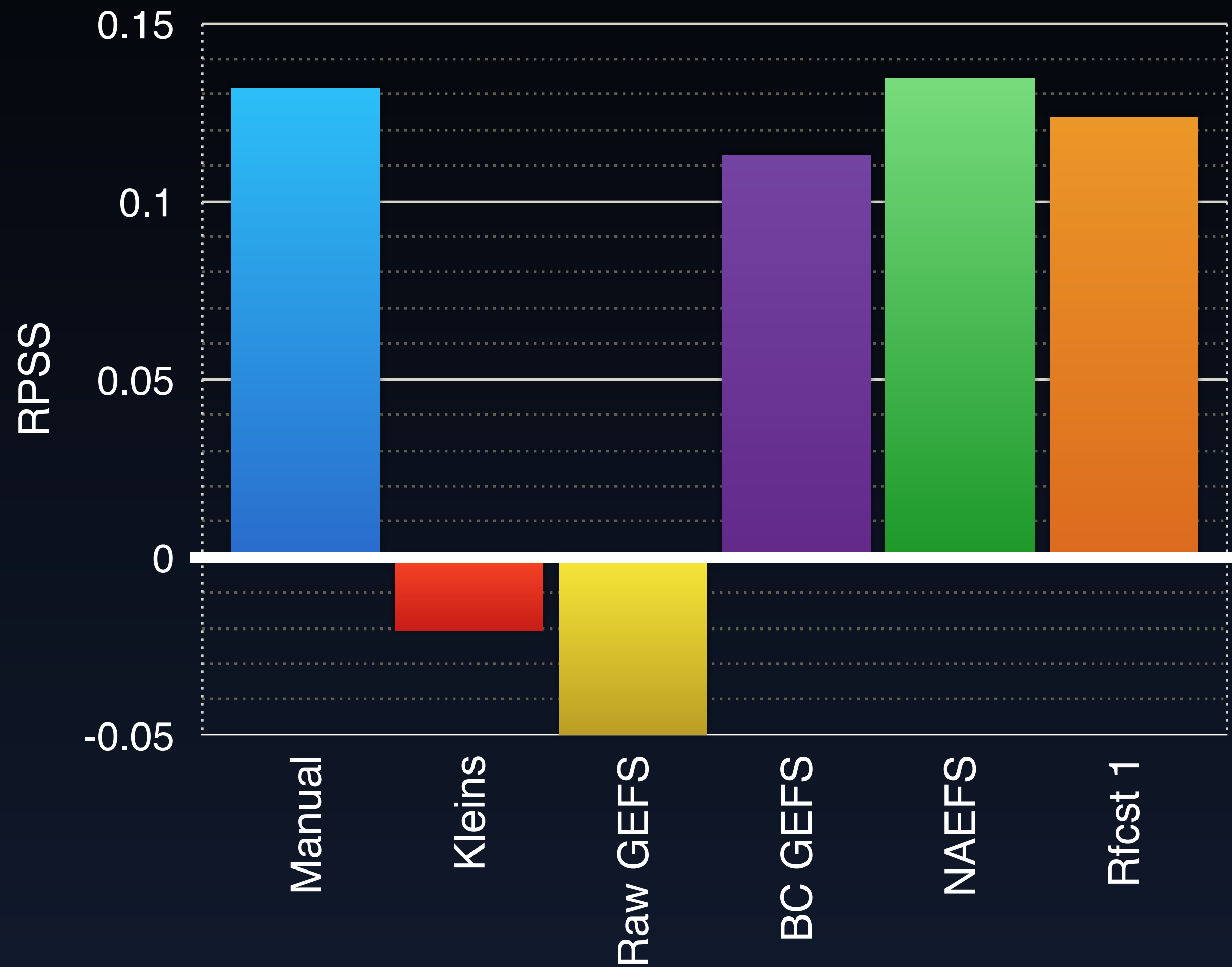


Reforecast-1 Dataset

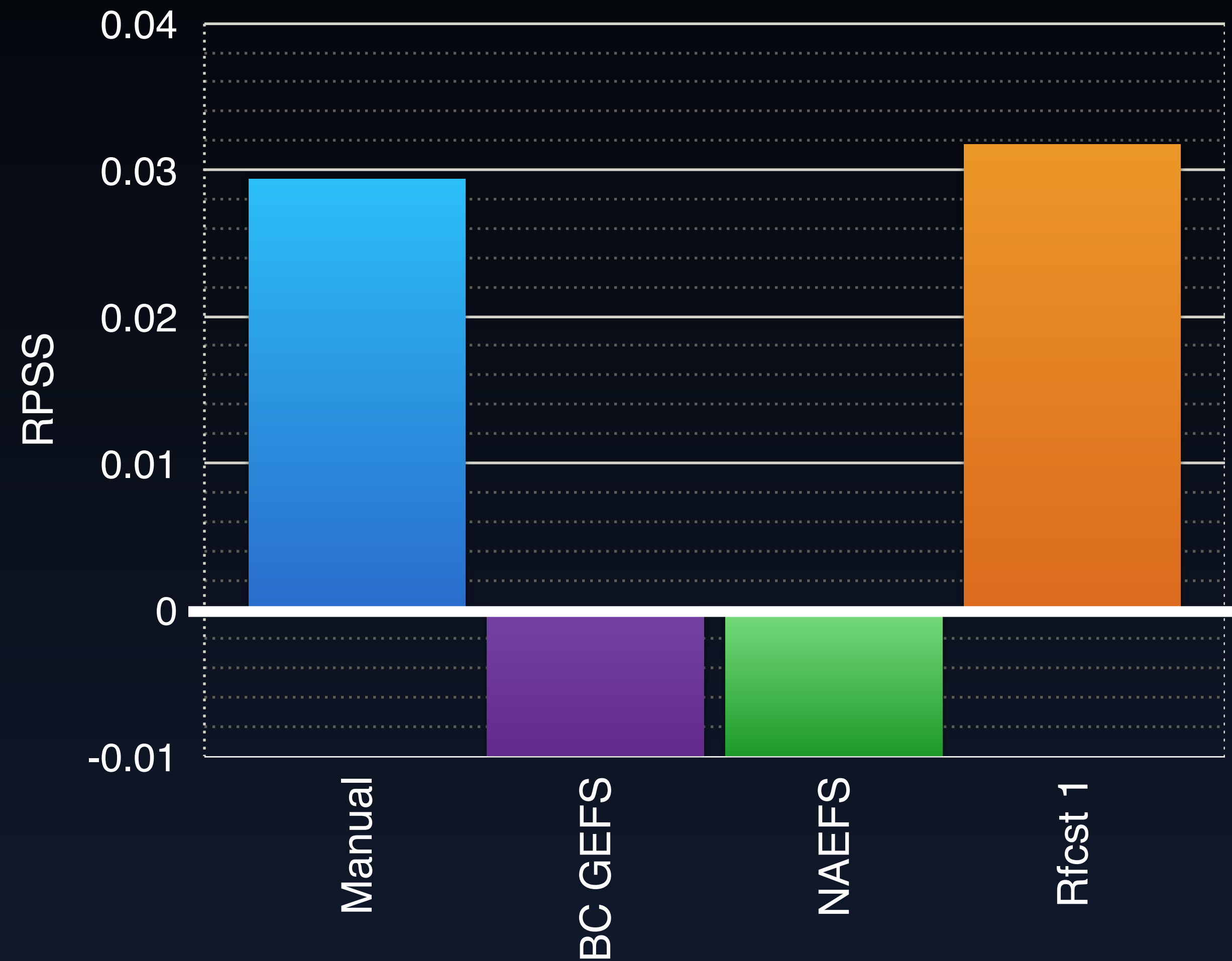
- Produced by the Earth System Research Lab (ESRL)
- 1998 NCEP Global Ensemble Forecasting System (GEFS)
- 11 members
- Initialized daily at 00z using NCEP/NCAR reanalysis from 1979 to mid-2013
- Resolution of T62 (about 175 km)

Reforecast-1 Skill - RPSS

RPSS - Temperature - 2010 to Present

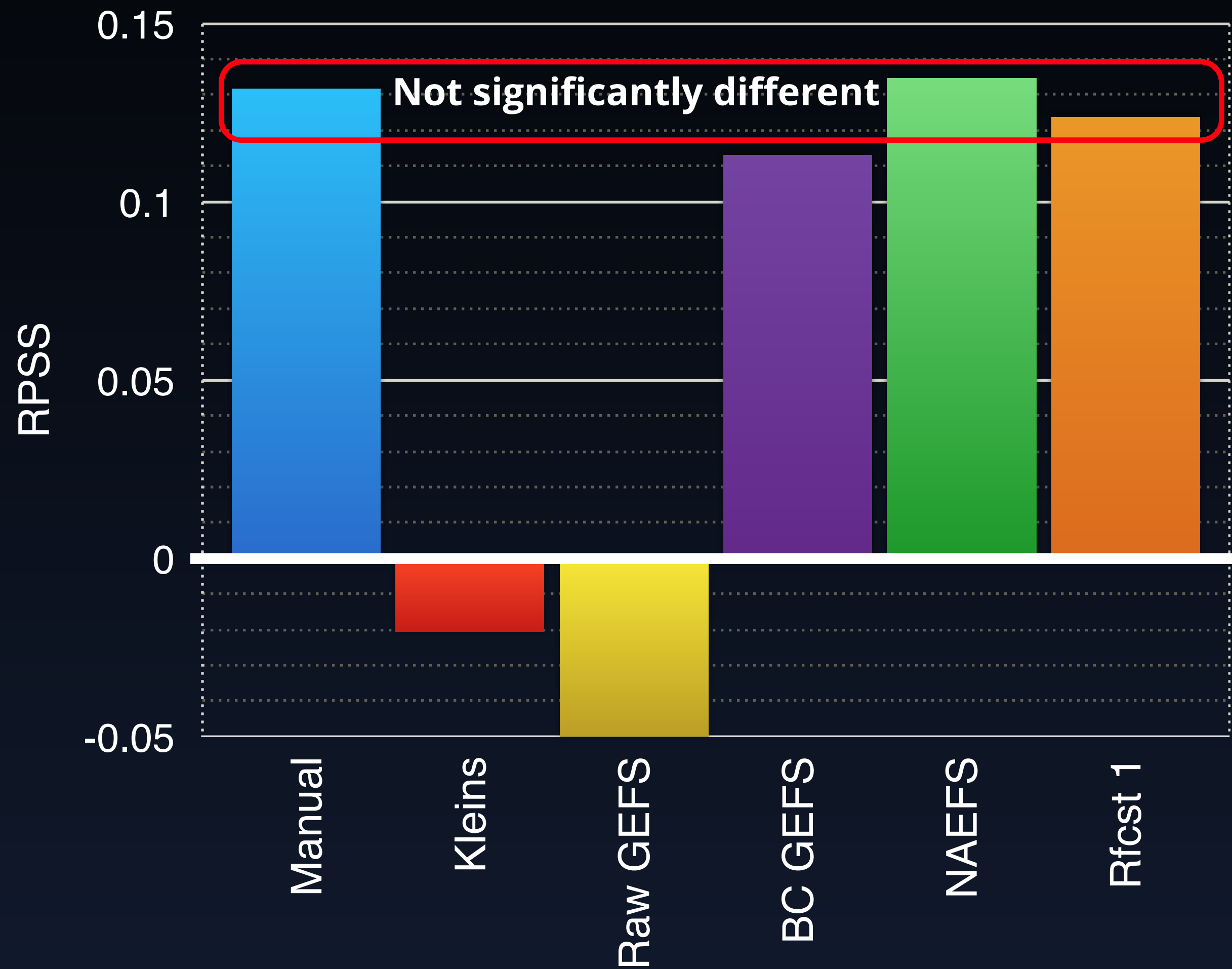


RPSS - Precipitation - 2010 to Present

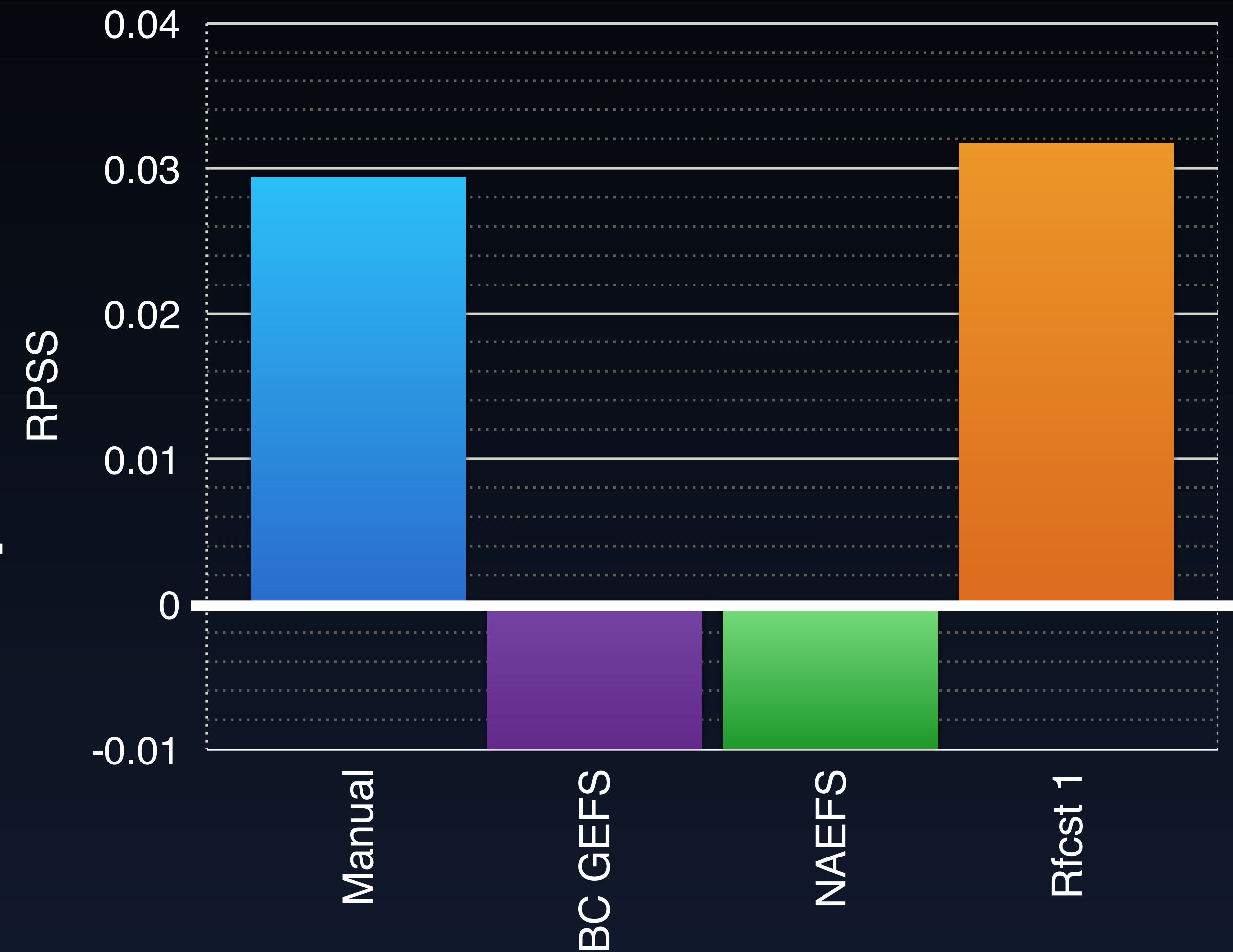


Reforecast-1 Skill - RPSS

RPSS - Temperature - 2010 to Present

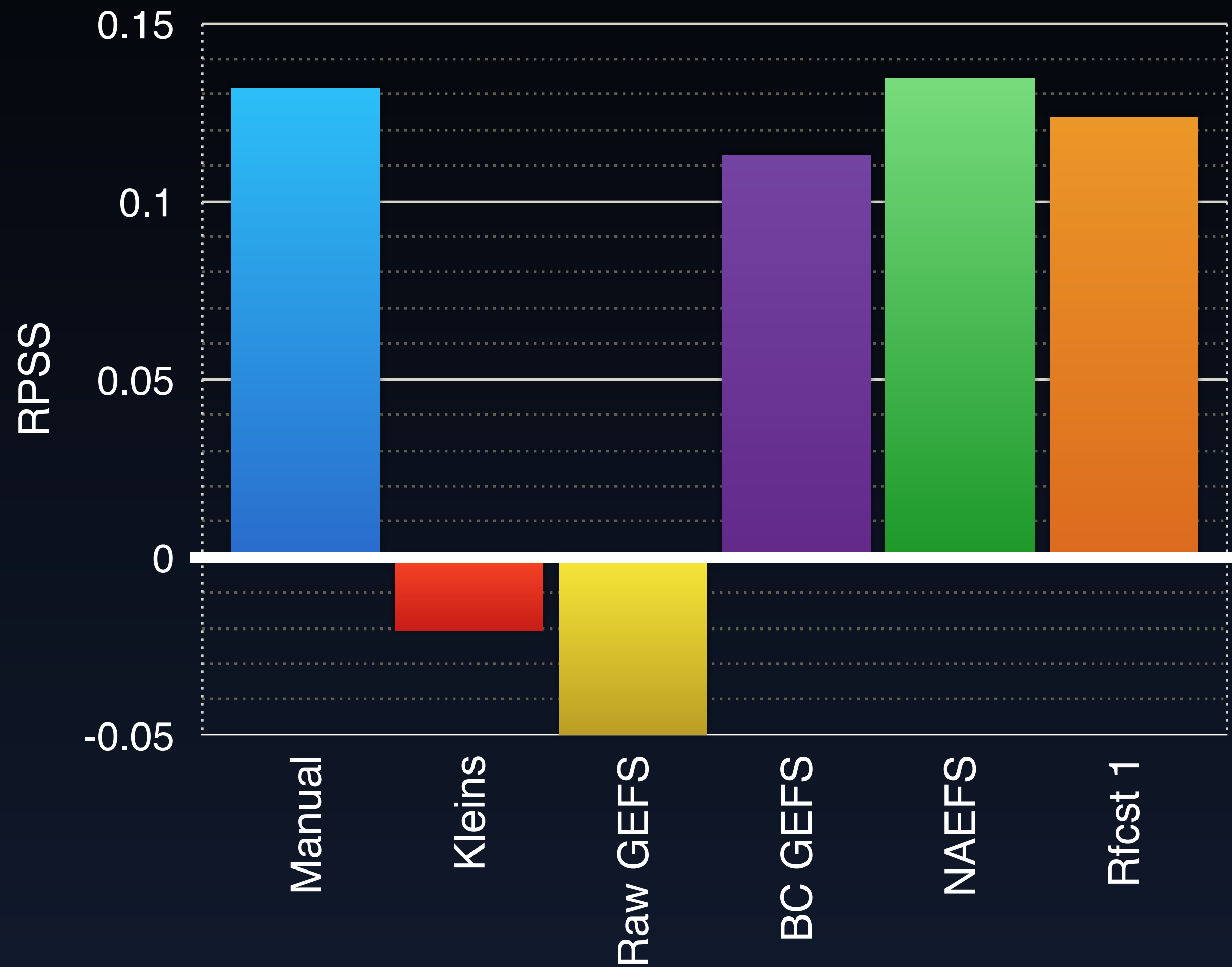


RPSS - Precipitation - 2010 to Present

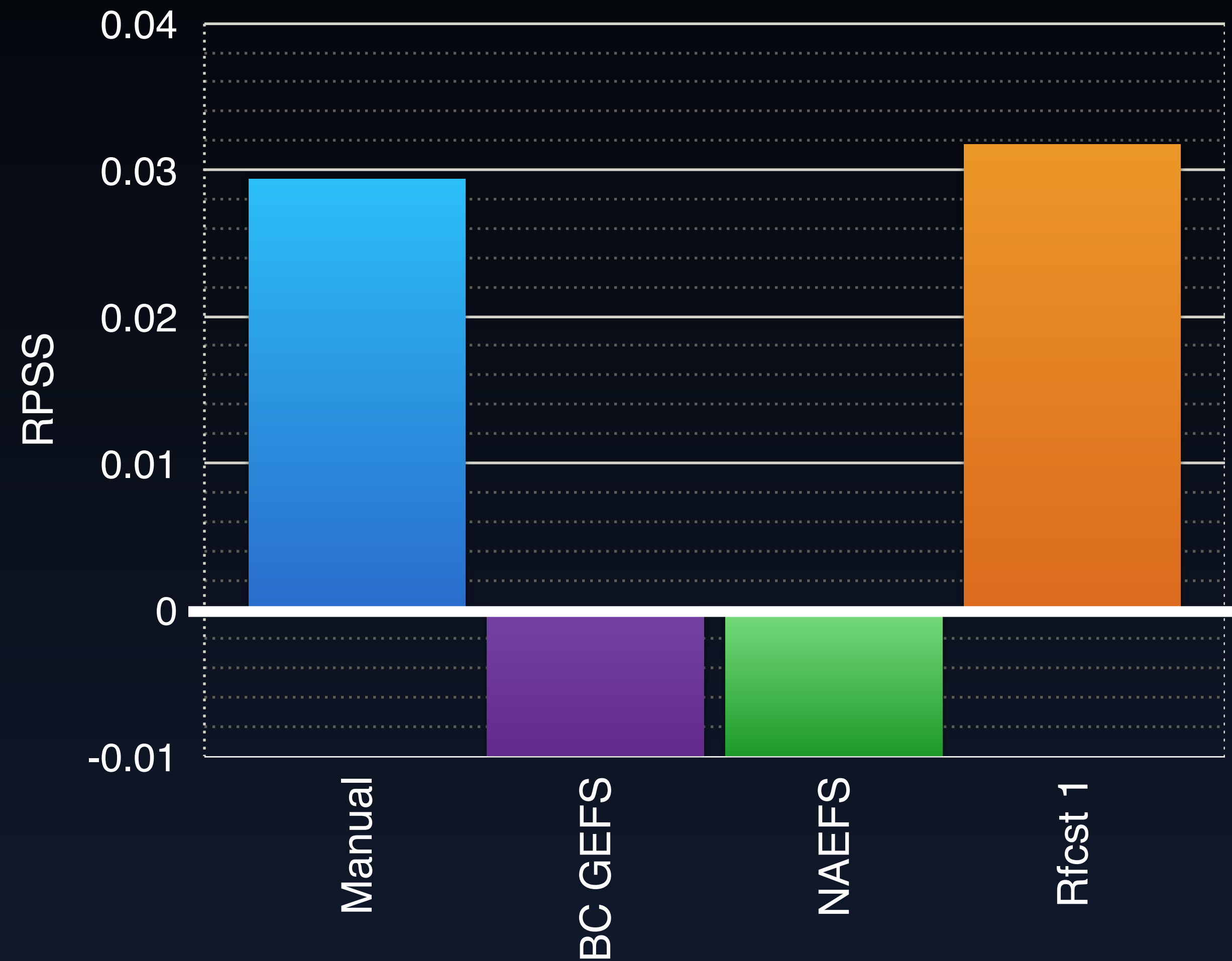


Reforecast-1 Skill - RPSS

RPSS - Temperature - 2010 to Present

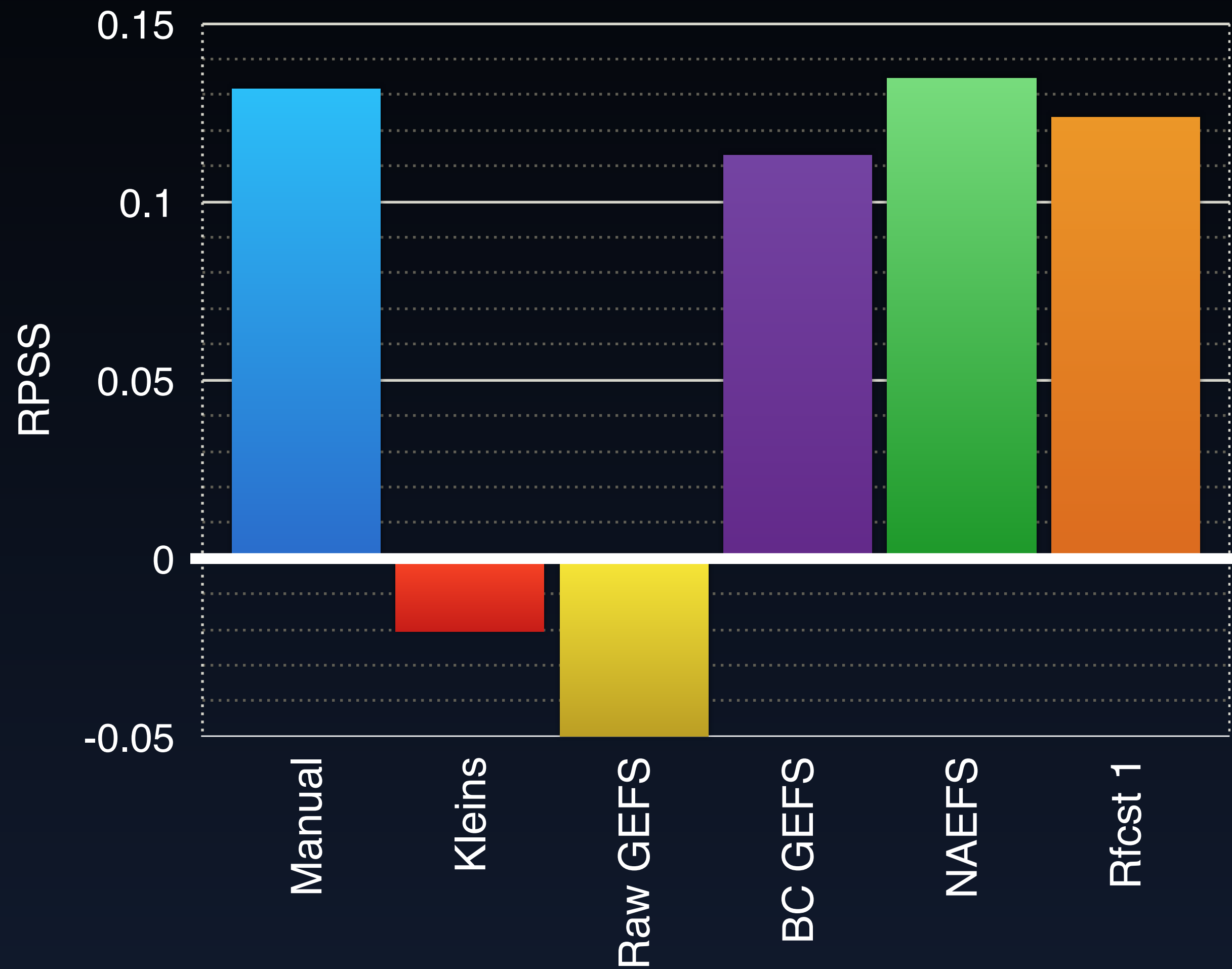


RPSS - Precipitation - 2010 to Present

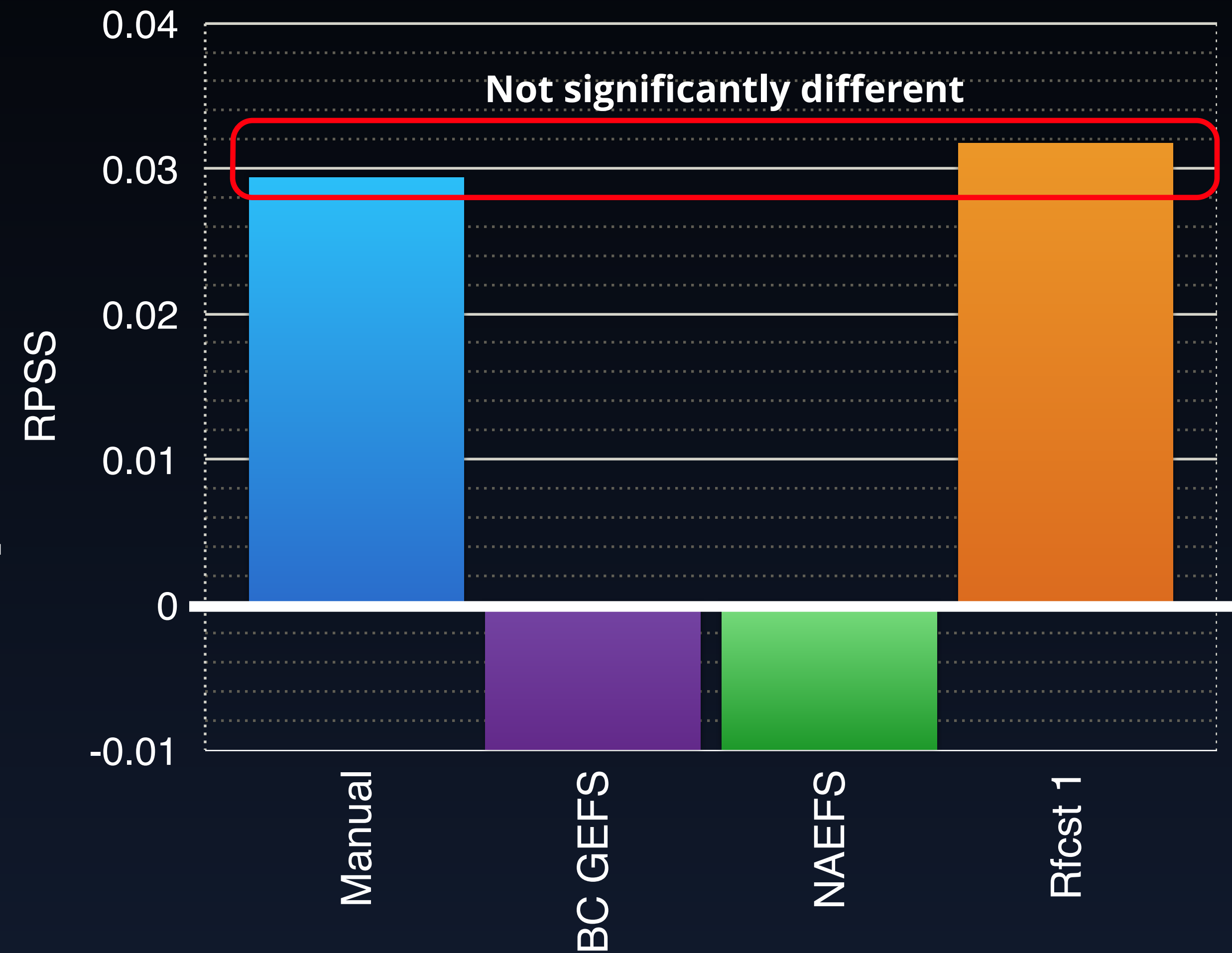


Reforecast-1 Skill - RPSS

RPSS - Temperature - 2010 to Present

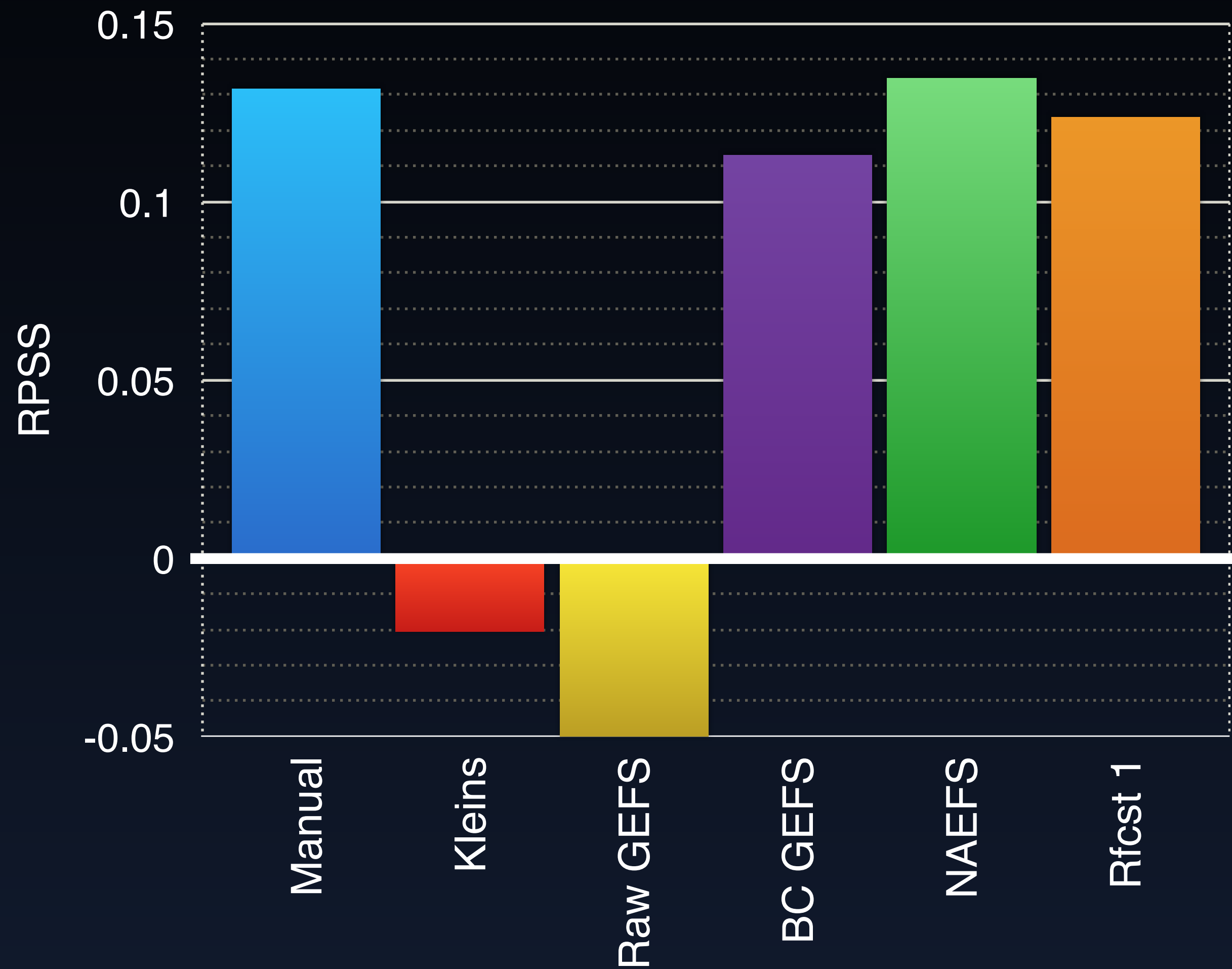


RPSS - Precipitation - 2010 to Present

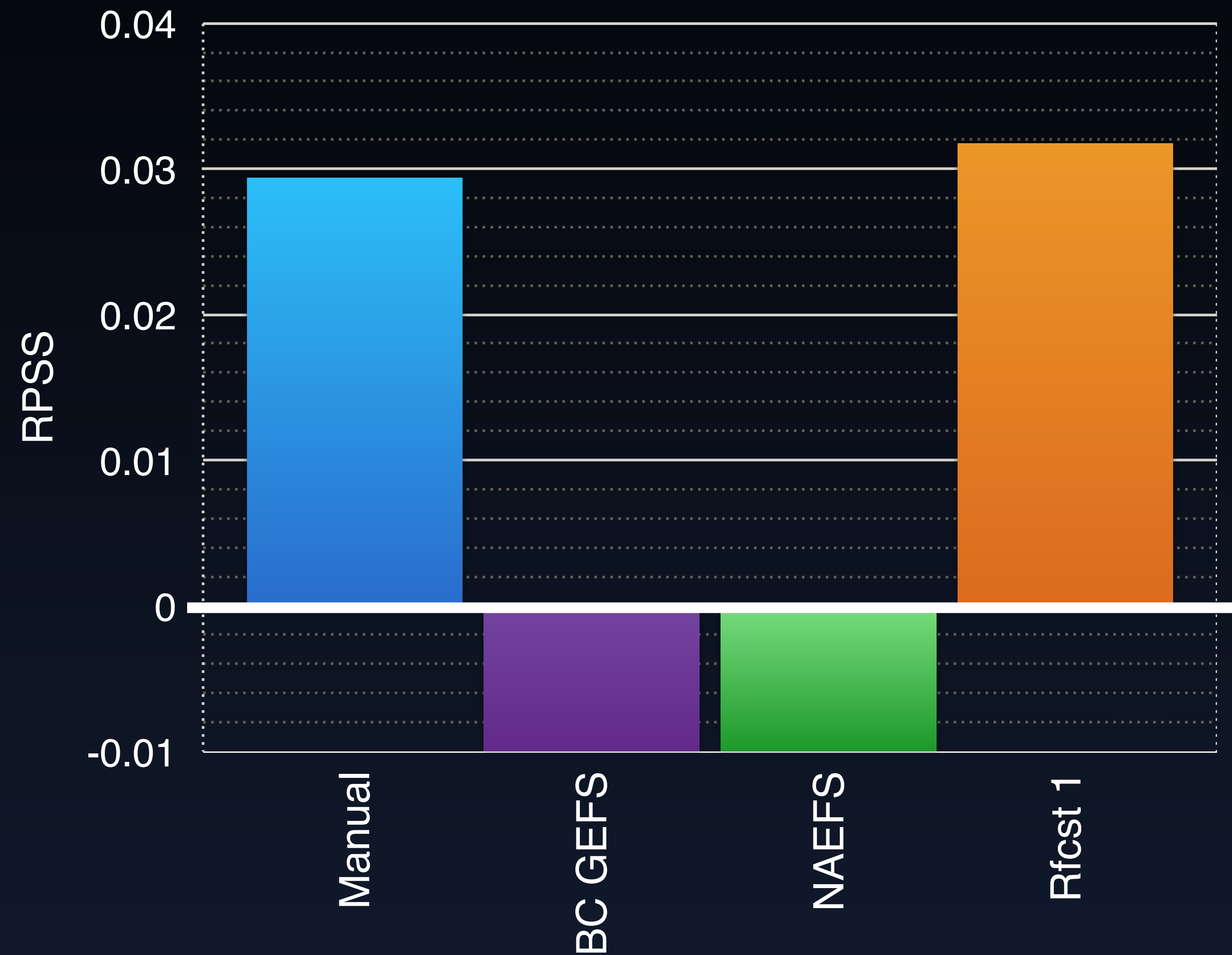


Reforecast-1 Skill - RPSS

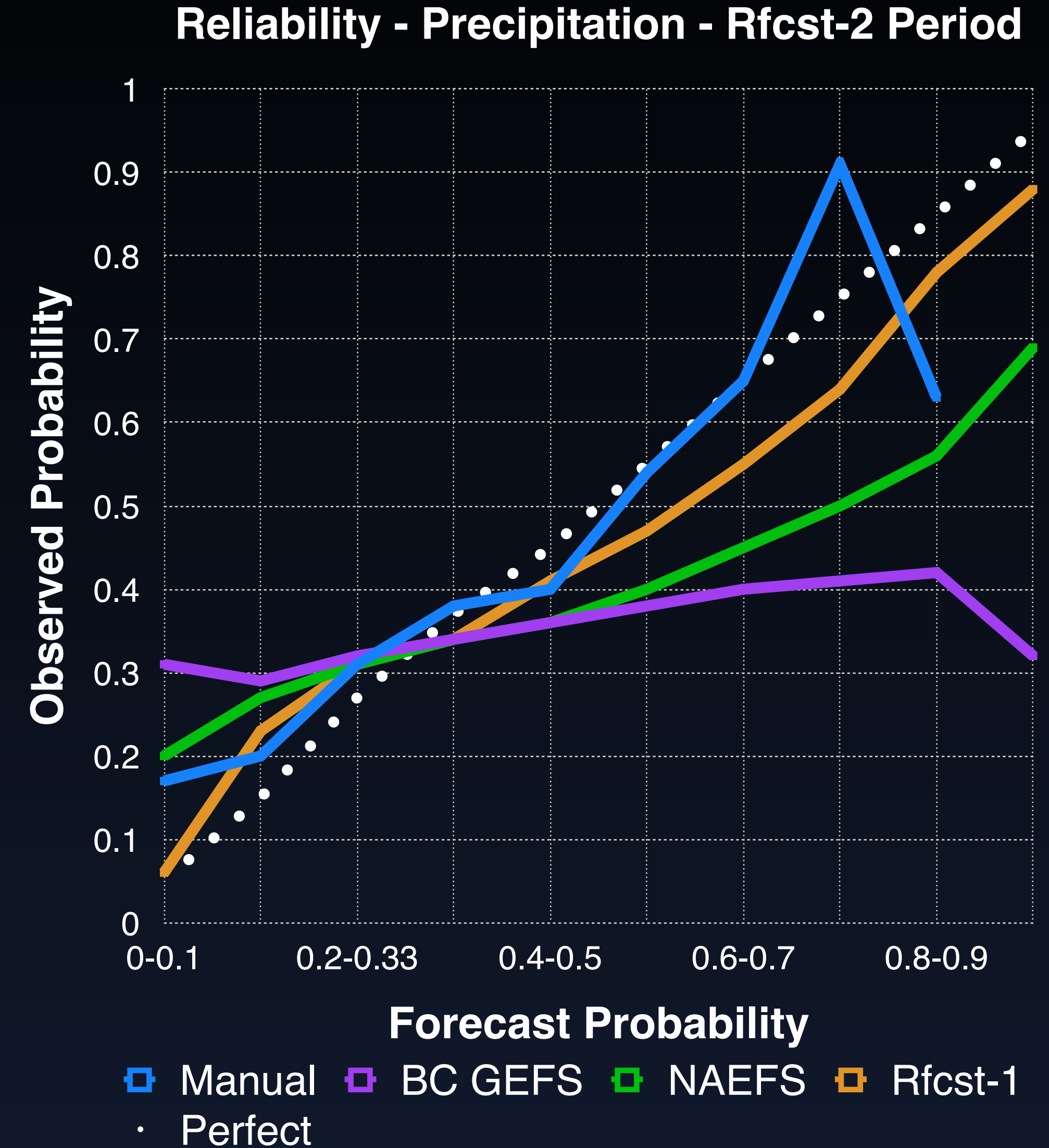
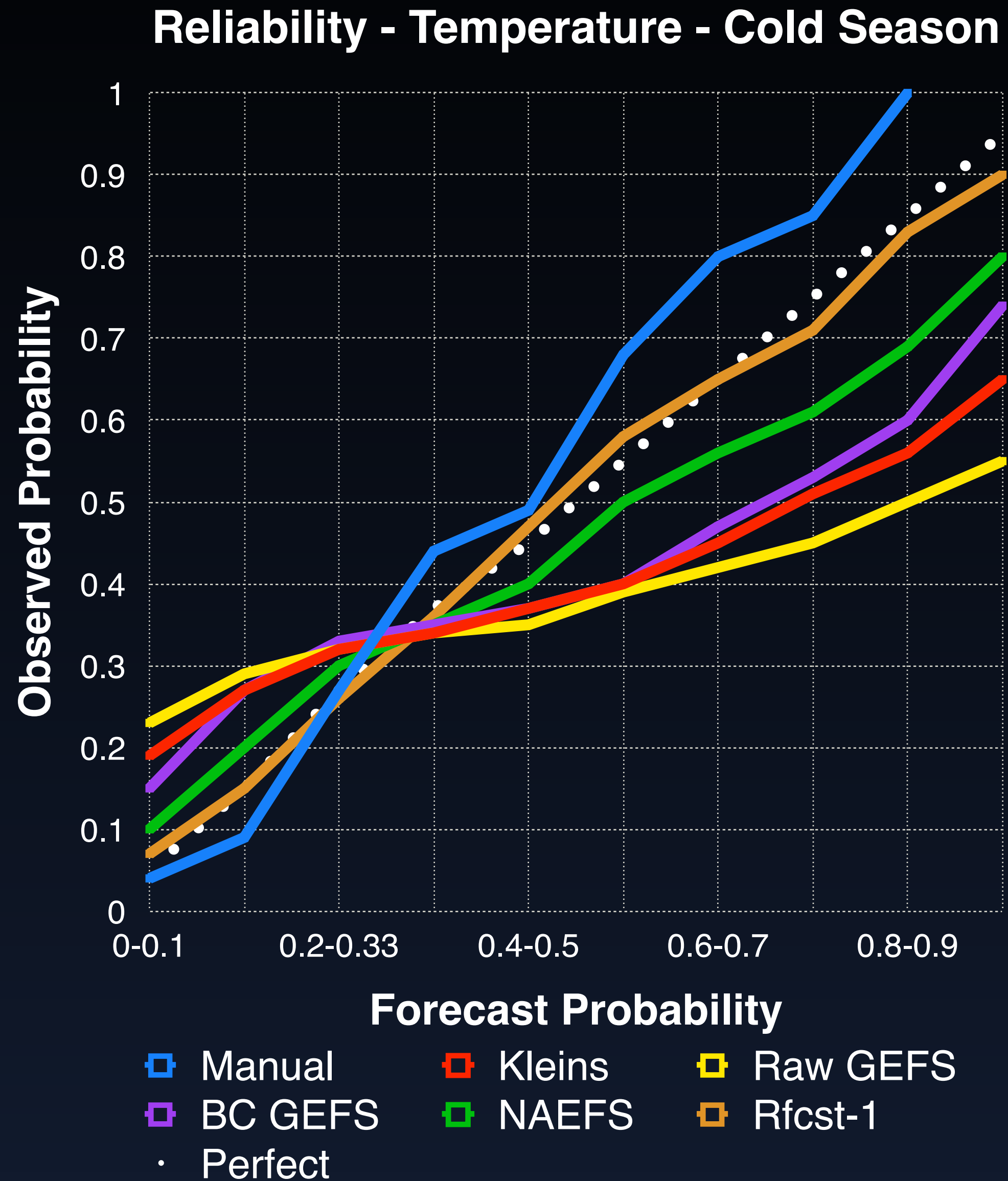
RPSS - Temperature - 2010 to Present



RPSS - Precipitation - 2010 to Present



Reforecast-1 Skill - Reliability



Issues with Reforecast-1

- Deprecated model (1998) with relatively low resolution
- Large-scale pattern forecast by 1998-GEFS sometimes very poor
- **1998 GEFS was being retired by mid-2013**

ESRL's New Reforcast-2

- Produced by ESRL
- 2012 NCEP GEFS
- 11 members
- Initialized daily at 00z using CFSR from Dec 1984 to present
- Resolution of T254 (about 50 km) out to 8 days, and T190 (about 70 km) from 8-16 days

CPC's Reforecast Calibration Project

Goals:

1. Replace the Reforecast-1 tool since it was being retired
2. Provide a skillful tool for CPC's week-2 forecasters

Accomplishments:

1. Created development plan
2. Gathered data
3. Wrote all necessary software
4. Produced a product

Reforecast Calibration Steps

1

Obtain
reforecast data

```
1985010100/c00/tmp_2m_1985010100.grib2
1985010100/p01/tmp_2m_1985010100.grib2
1985010100/p02/tmp_2m_1985010100.grib2
1985010100/p03/tmp_2m_1985010100.grib2
1985010100/p04/tmp_2m_1985010100.grib2
1985010100/p05/tmp_2m_1985010100.grib2
1985010100/p06/tmp_2m_1985010100.grib2
1985010100/p07/tmp_2m_1985010100.grib2
1985010100/p08/tmp_2m_1985010100.grib2
1985010100/p09/tmp_2m_1985010100.grib2
1985010100/p10/tmp_2m_1985010100.grib2
```

2

Generate
statistics

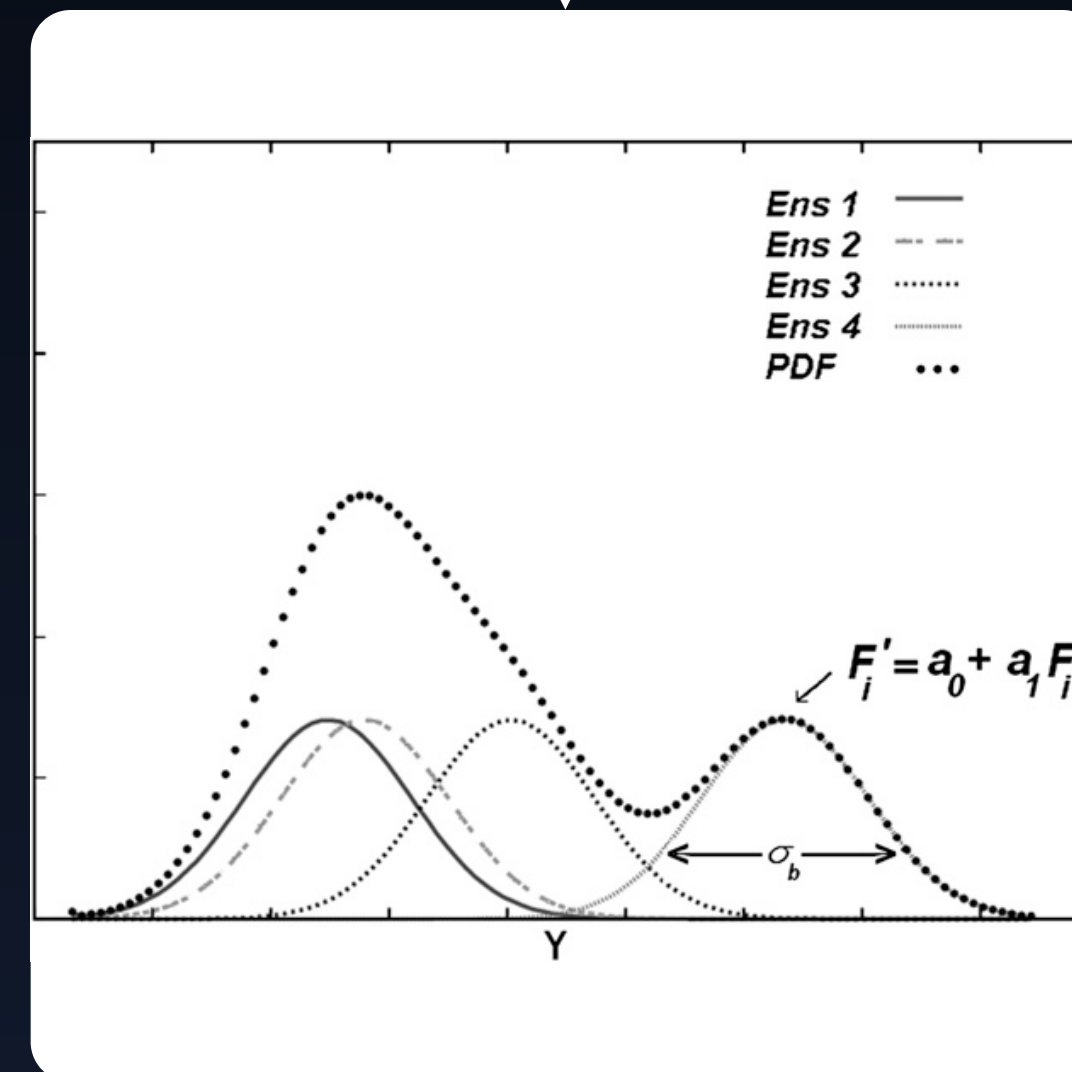
$$\bar{X} = \frac{\sum_{i=1}^{i=n} X_i}{n}$$

$$\sigma(x, y) = E[(x - E[x])(y - E[y])]$$

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \mu)^2}$$

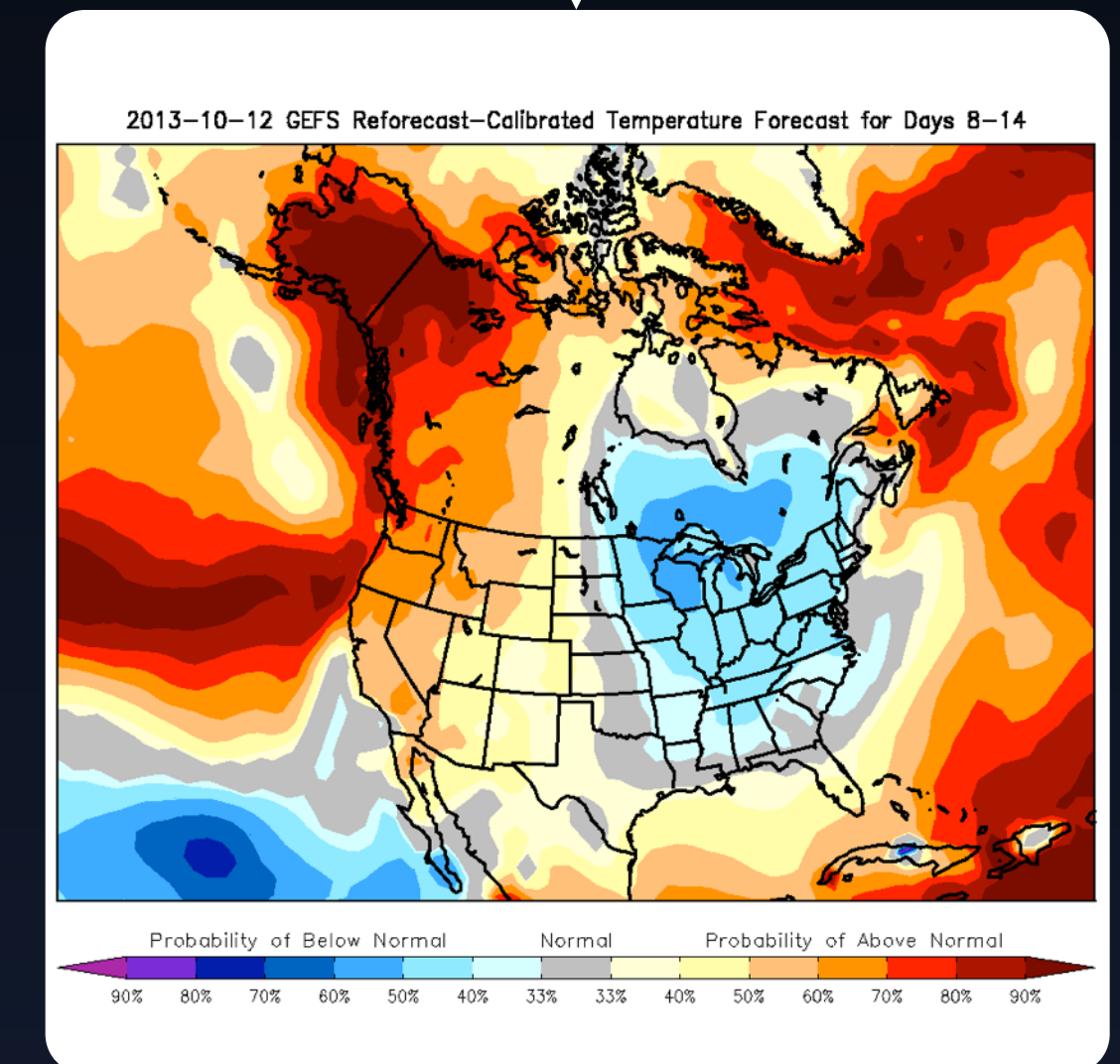
3

Calibrate realtime
ensemble



4

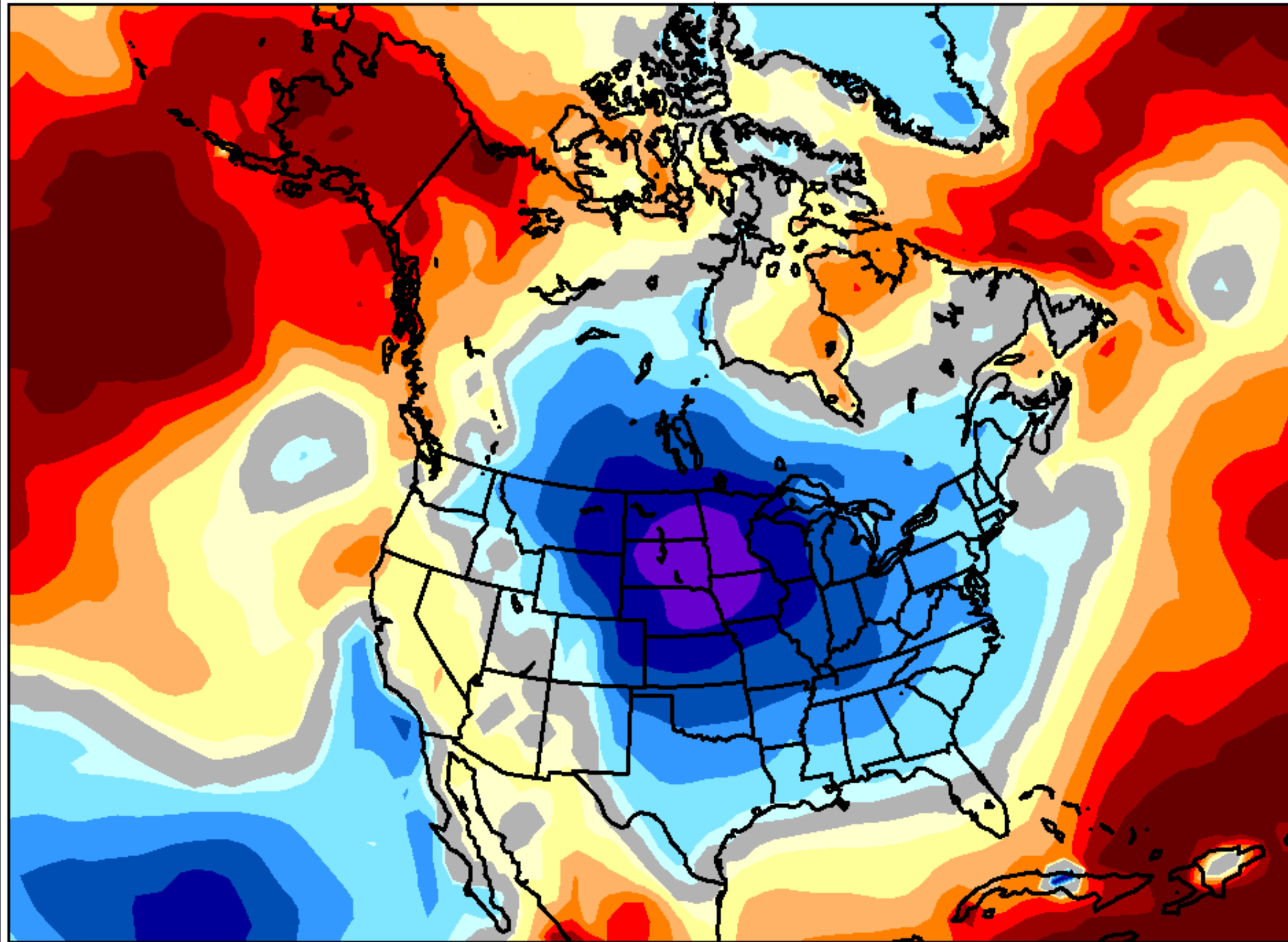
Produce product
for forecasters



Reforecast-Calibrated Forecast

Temperature

2013-10-16 GEFS Reforecast-Calibrated Temperature Forecast for Days 8-14

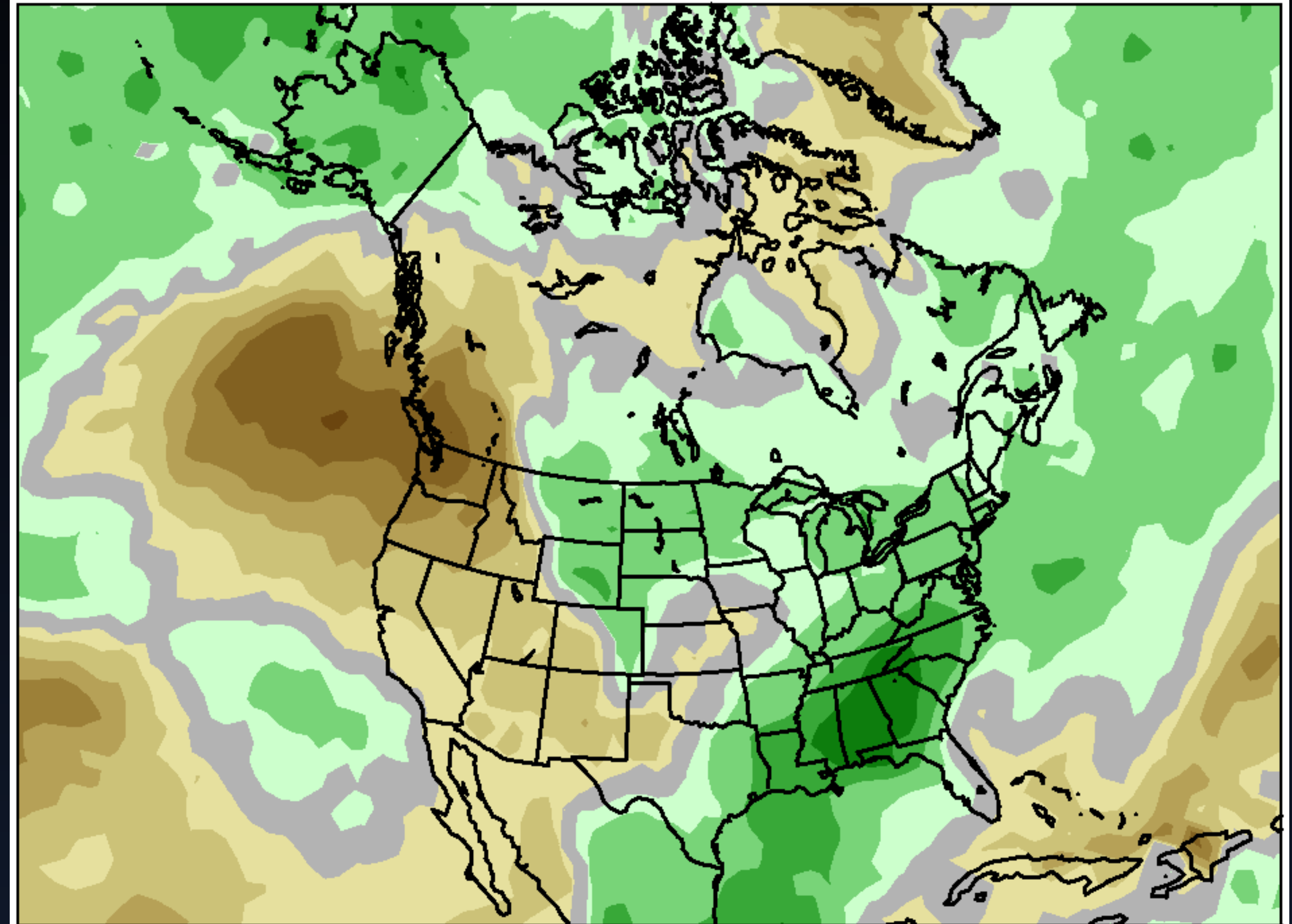


Probability of Below Normal Normal Probability of Above Normal

90% 80% 70% 60% 50% 40% 33% 33% 40% 50% 60% 70% 80% 90%

Precipitation

2013-10-16 GEFS Reforecast-Calibrated Precipitation Forecast for Days 8-14

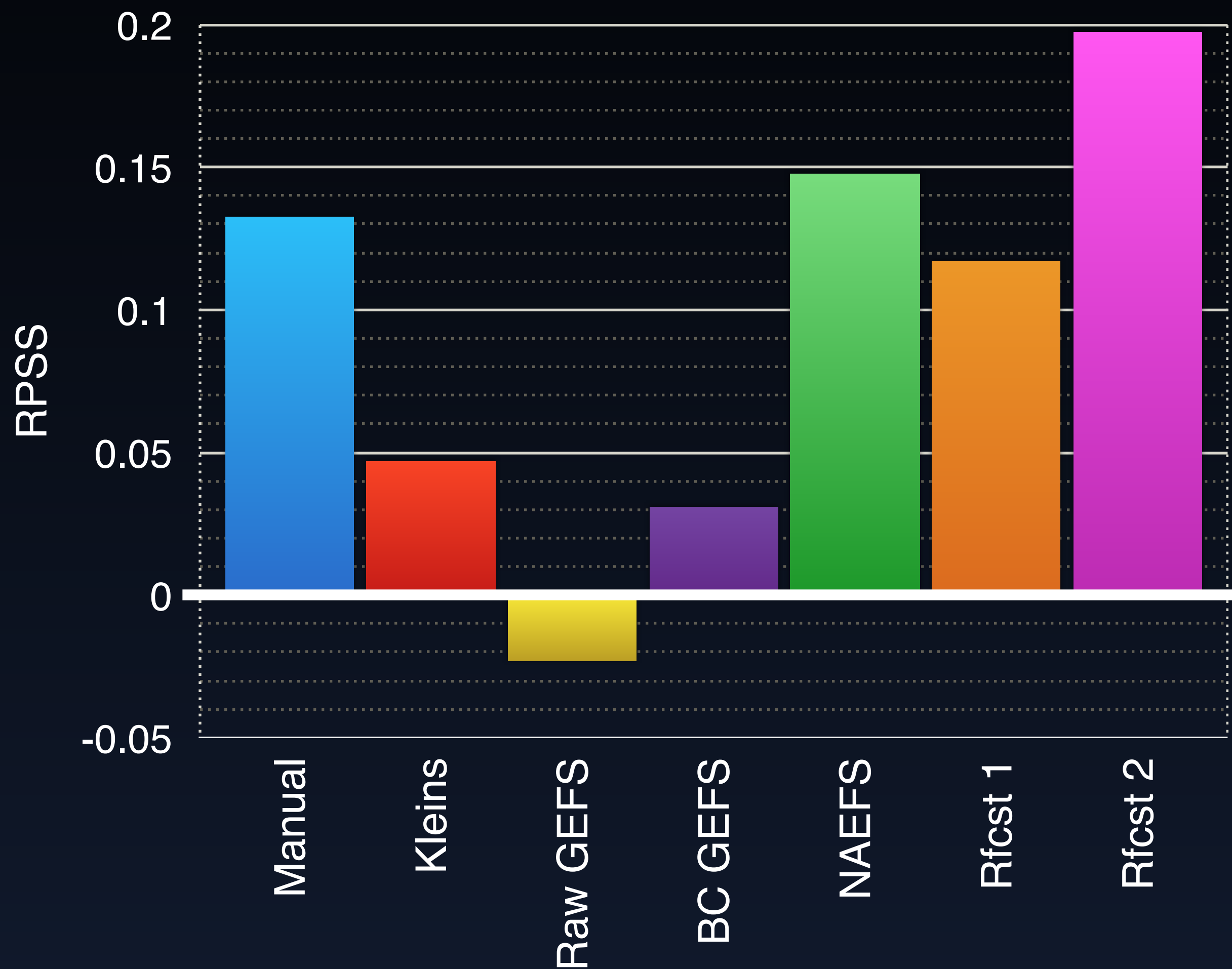


Probability of Below Median Median Probability of Above Median

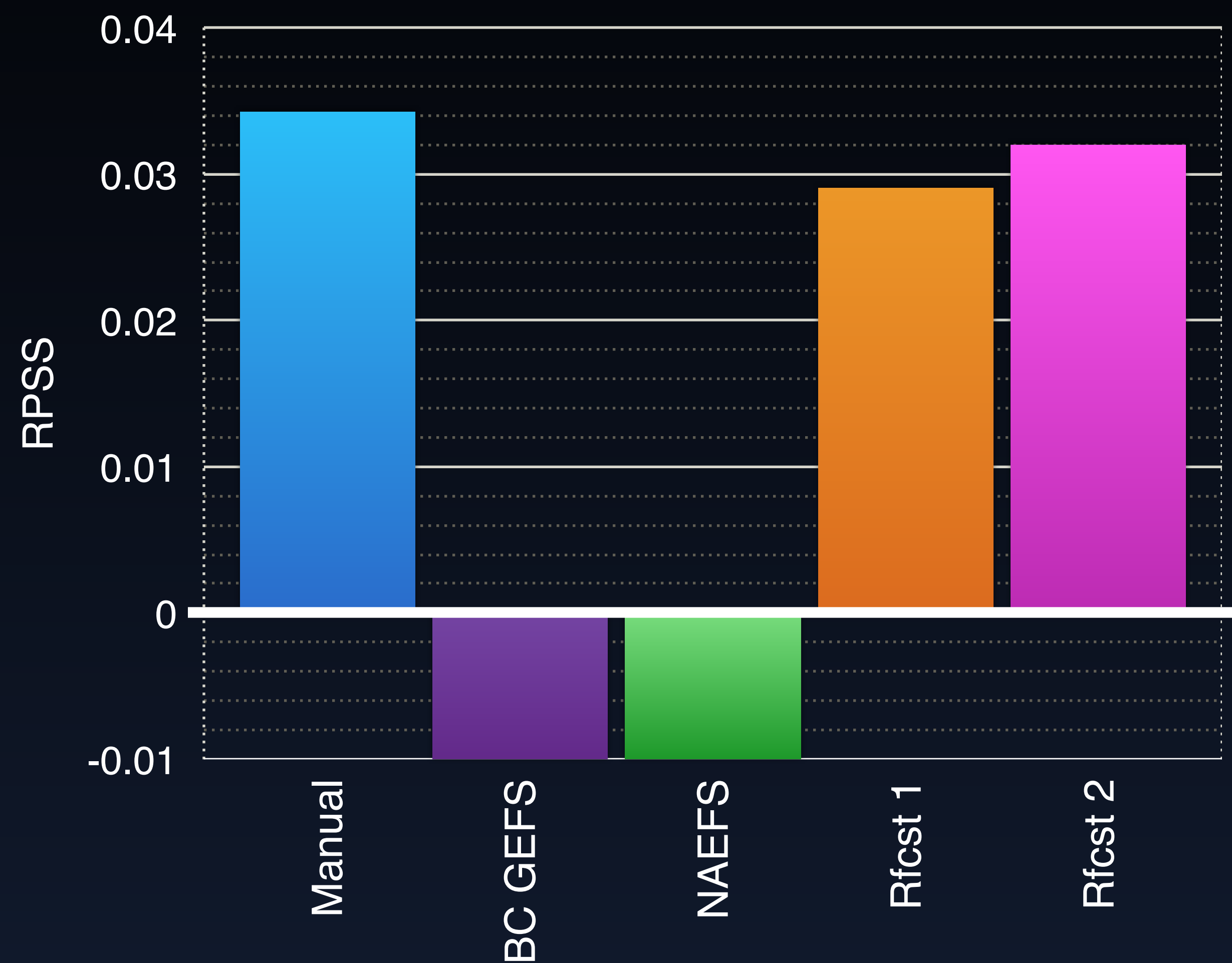
90% 80% 70% 60% 50% 40% 33% 33% 40% 50% 60% 70% 80% 90%

Reforecast 2 Skill - RPSS

RPSS - Temperature - Cold Season

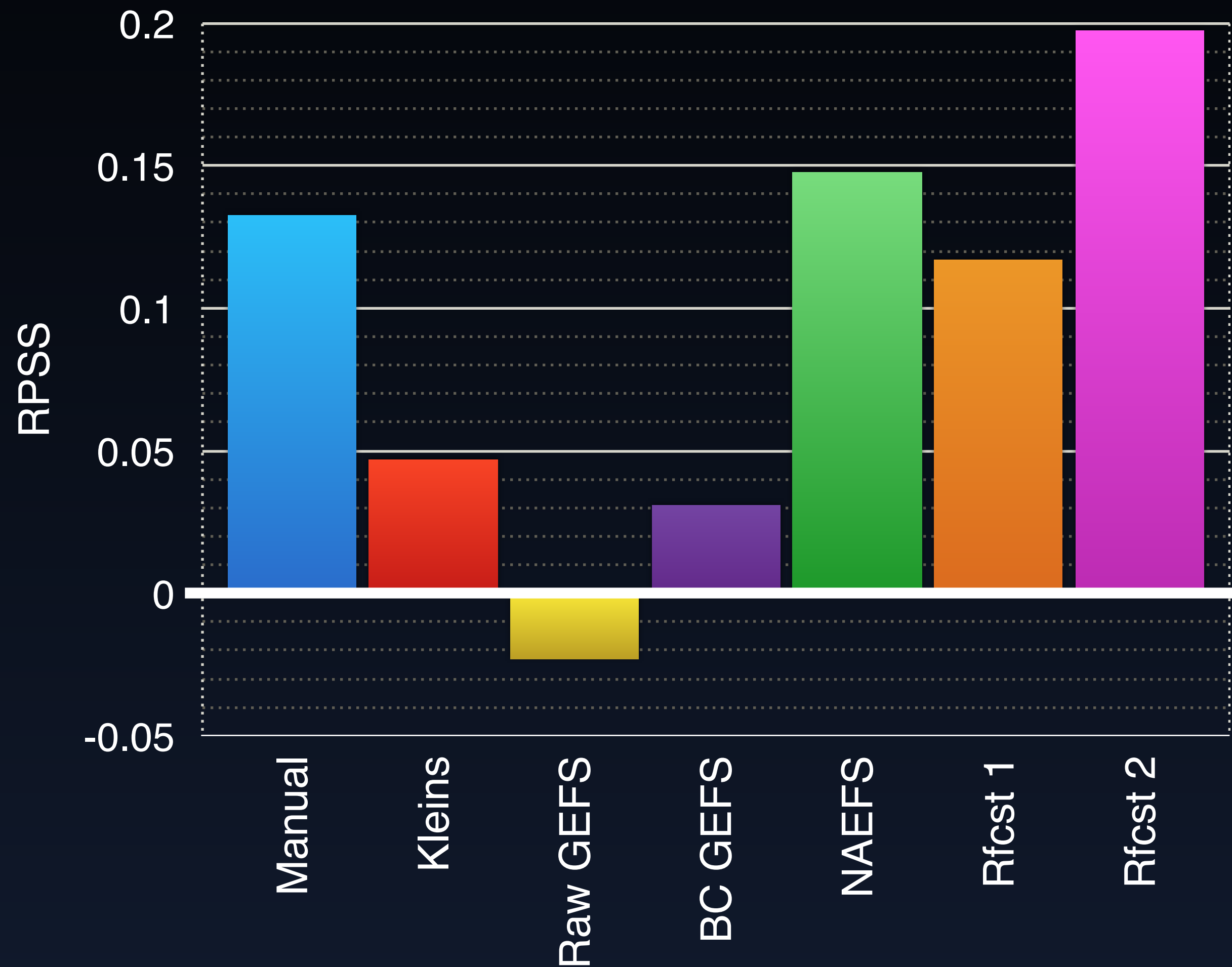


RPSS - Precipitation - Reforecast-2 Period

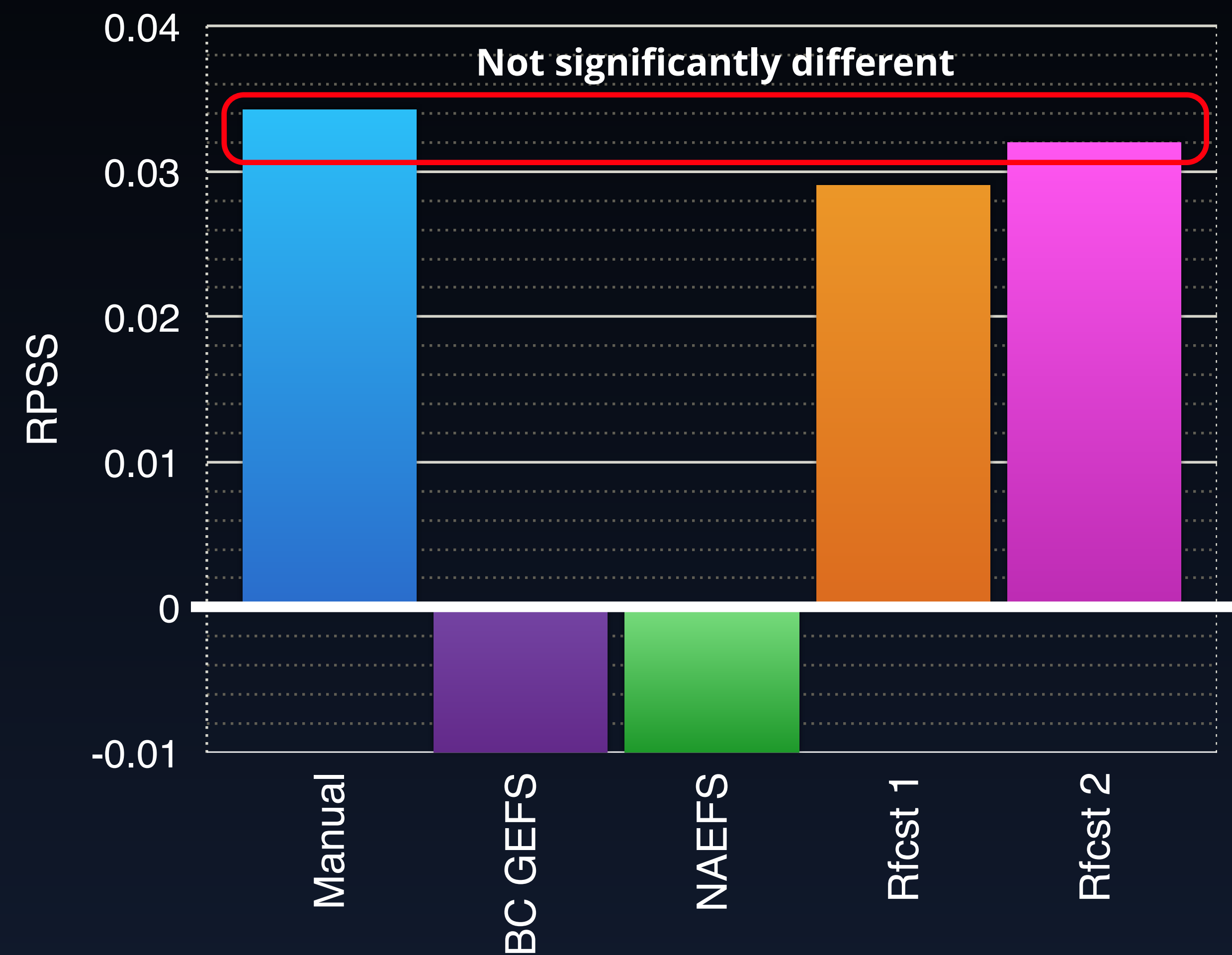


Reforecast 2 Skill - RPSS

RPSS - Temperature - Cold Season

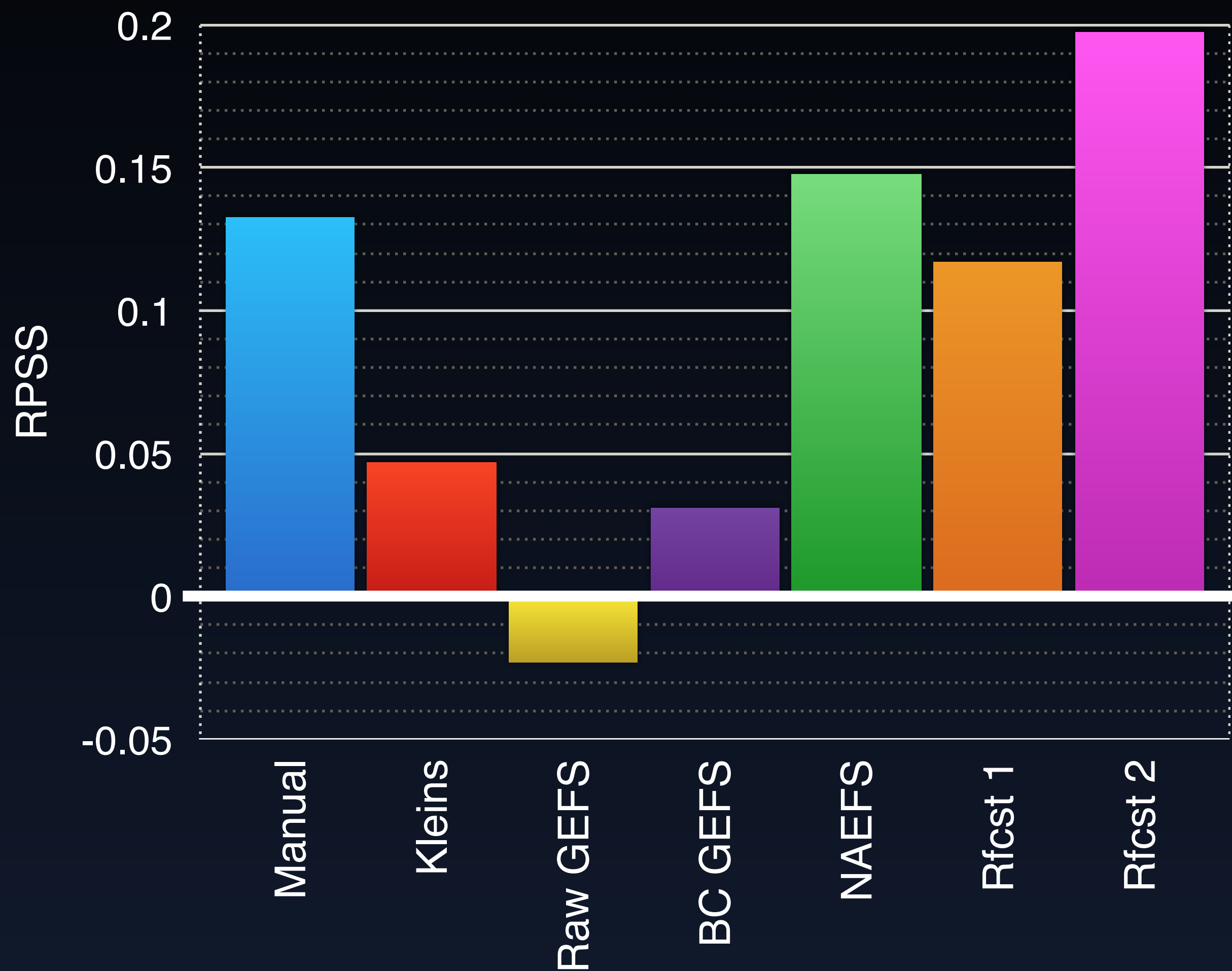


RPSS - Precipitation - Reforecast-2 Period

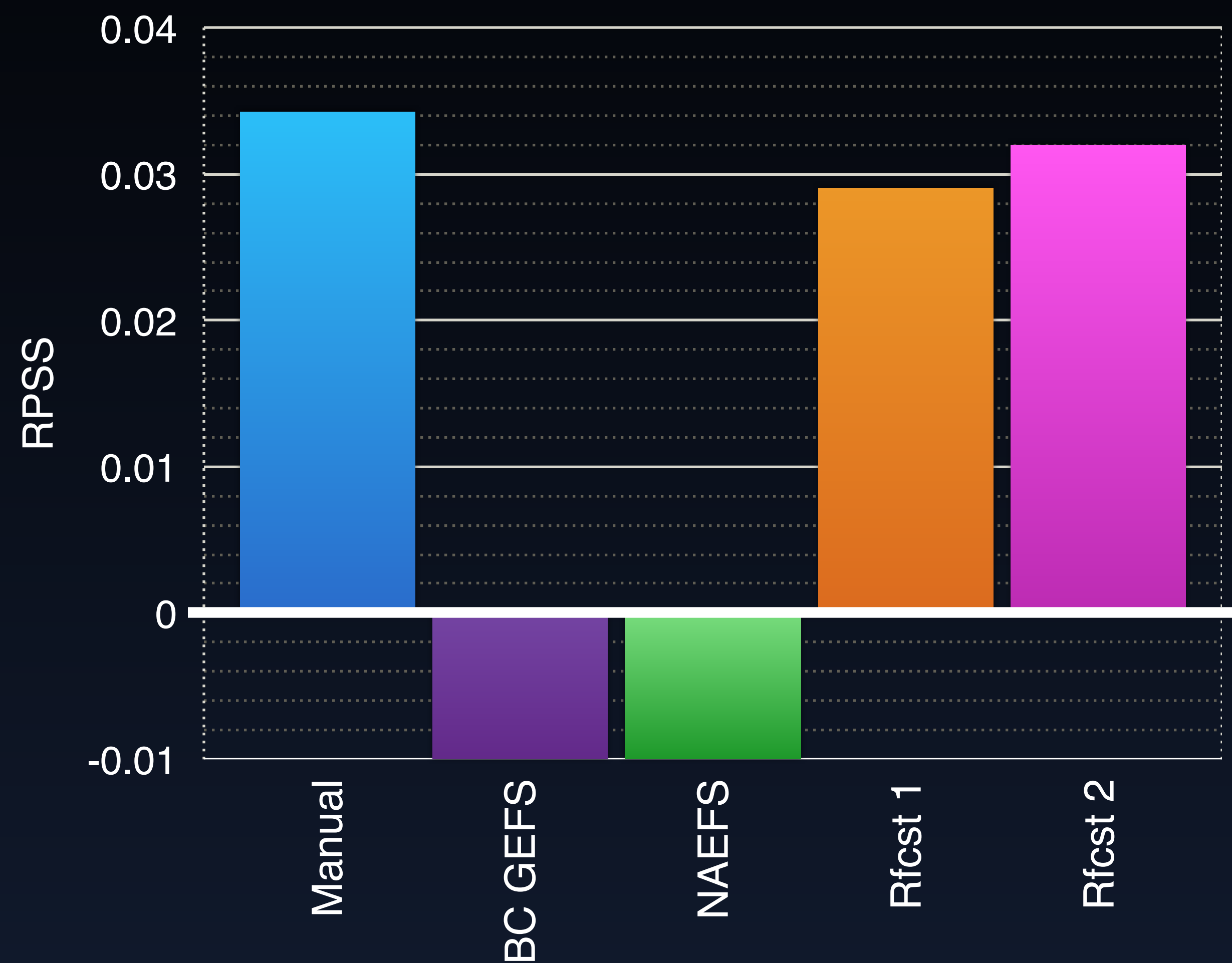


Reforecast 2 Skill - RPSS

RPSS - Temperature - Cold Season

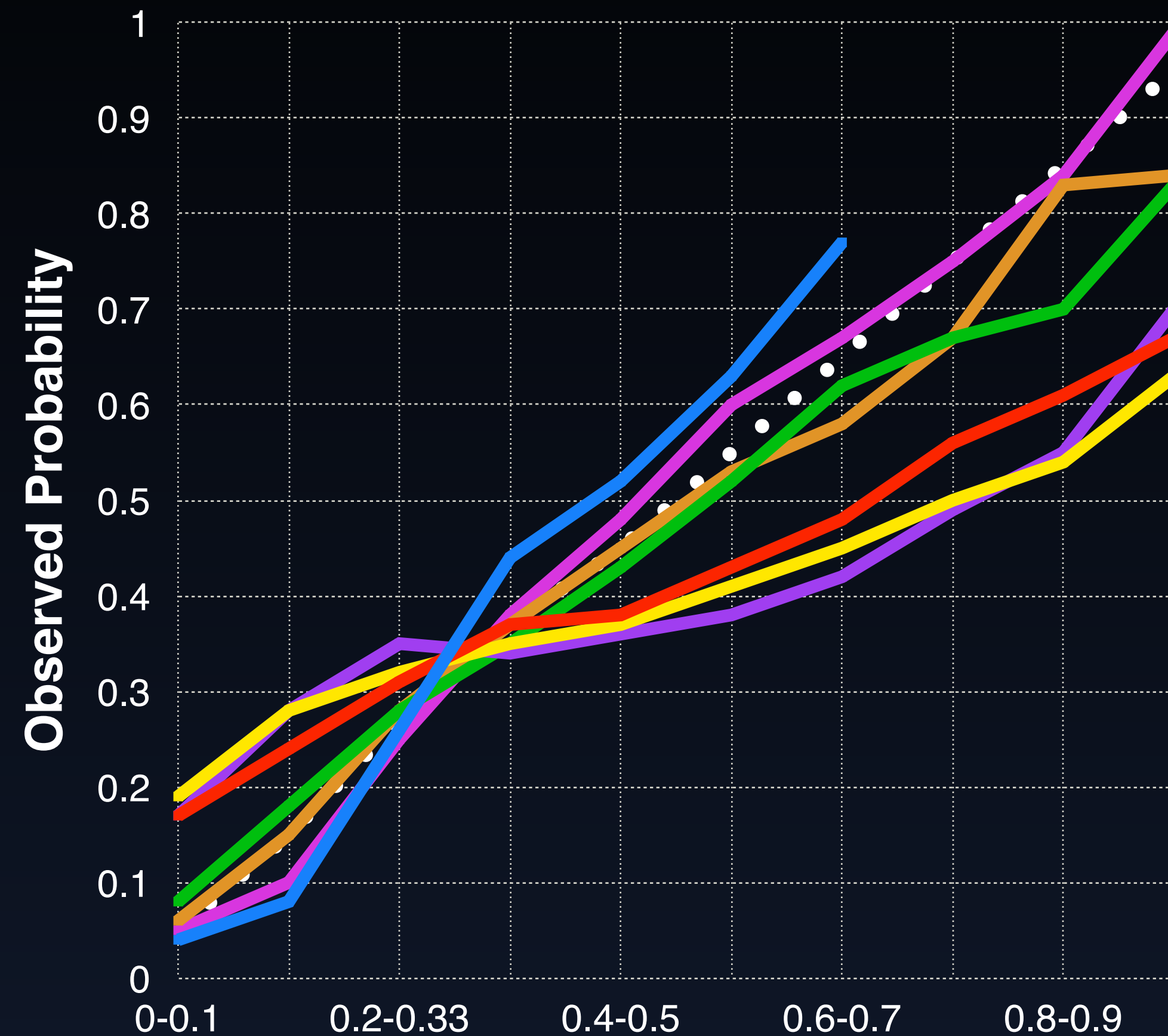


RPSS - Precipitation - Reforecast-2 Period



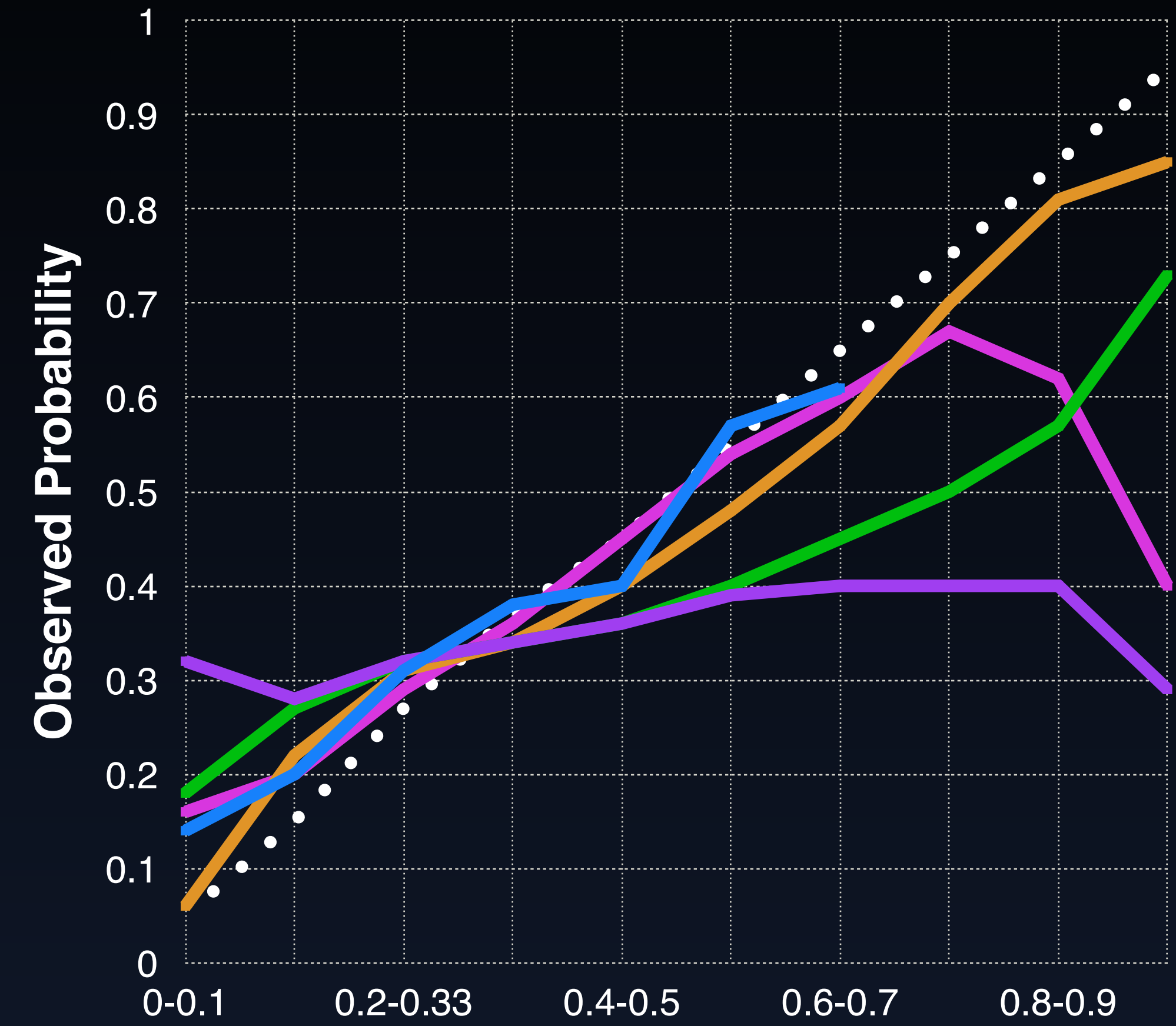
Reforecast 2 Skill - Reliability

Reliability - Temperature - Cold Season



Manual BC GEFS Rfcst 2
Kleins NAEFS Rfcst 1
Raw GEFS Perfect

Reliability - Precipitation - Rfcst-2 Period



Manual BC GEFS NAEFS Rfcst-1
Rfcst-2 Perfect

Conclusions

- Reforecast-1 tool has significantly higher skill than raw GEFS
- Reforecast-2 tool has significantly higher skill than reforecast-1 tool
- Reforecast-2 tool is CPC's most skillful week-2 forecast tool (during the cold season)
- CPC's Reforecast Calibration Project was a **success**:
 - Created a forecast tool that could replace the retiring Reforecast-1 tool
 - Created a skillful tool to potentially improve CPC's Week-2 forecast



Thanks

- CPC Reforecast Calibration Project Members (Dan Collins, Emily Riddle, Melissa Ou, and others)
- Earth System Research Laboratory (created both reforecast datasets)